

**Operational Plan: Yentna River Chinook Salmon  
Sampling and Lake Creek Chinook Salmon Sonar  
Assessment, 2022**

by

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and

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May 2022

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Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code		all standard mathematical signs, symbols and abbreviations	
deciliter	dL		AAC		
gram	g	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H <sub>A</sub>
hectare	ha			base of natural logarithm	e
kilogram	kg	all commonly accepted		catch per unit effort	CPUE
kilometer	km	professional titles	e.g., Dr., Ph.D., R.N., etc.	coefficient of variation	CV
liter	L			common test statistics	(F, t, $\chi^2$ , etc.)
meter	m	at	@	confidence interval	CI
milliliter	mL	compass directions:		correlation coefficient (multiple)	R
millimeter	mm	east	E	correlation coefficient (simple)	r
<b>Weights and measures (English)</b>		north	N	covariance	cov
cubic feet per second	ft <sup>3</sup> /s	south	S	degree (angular)	°
foot	ft	west	W	degrees of freedom	df
gallon	gal	copyright	©	expected value	E
inch	in	corporate suffixes:		greater than	>
mile	mi	Company	Co.	greater than or equal to	≥
nautical mile	nmi	Corporation	Corp.	harvest per unit effort	HPUE
ounce	oz	Incorporated	Inc.	less than	<
pound	lb	Limited	Ltd.	less than or equal to	≤
quart	qt	District of Columbia	D.C.	logarithm (natural)	ln
yard	yd	et alii (and others)	et al.	logarithm (base 10)	log
<b>Time and temperature</b>		et cetera (and so forth)	etc.	logarithm (specify base)	log <sub>2</sub> , etc.
day	d	exempli gratia (for example)	e.g.	minute (angular)	'
degrees Celsius	°C	Federal Information Code	FIC	not significant	NS
degrees Fahrenheit	°F	id est (that is)	i.e.	null hypothesis	H <sub>0</sub>
degrees kelvin	K	latitude or longitude	lat or long	percent	%
hour	h	monetary symbols		probability	P
minute	min	(U.S.)	\$, ¢	probability of a type I error (rejection of the null hypothesis when true)	α
second	s	months (tables and figures): first three letters	Jan,...,Dec	probability of a type II error (acceptance of the null hypothesis when false)	β
<b>Physics and chemistry</b>		registered trademark	®	second (angular)	"
all atomic symbols		trademark	™	standard deviation	SD
alternating current	AC	United States (adjective)	U.S.	standard error	SE
ampere	A	United States of America (noun)	USA	variance	
calorie	cal	U.S.C.	United States Code	population sample	Var var
direct current	DC	U.S. state	use two-letter abbreviations (e.g., AK, WA)		
hertz	Hz				
horsepower	hp				
hydrogen ion activity (negative log of)	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

***REGIONAL OPERATIONAL PLAN NO. ROP.SF.2A.2022.23***

**OPERATIONAL PLAN: YENTNA RIVER CHINOOK SALMON  
SAMPLING AND LAKE CREEK CHINOOK SALMON SONAR  
ASSESSMENT, 2022**

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May 2022

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*This document should be cited as follows:*

*DeCovich, N., J. Miller, and S. Dotomain. 2022. Operational Plan: Yentna River Chinook salmon sampling and Lake Creek Chinook salmon sonar assessment, 2022. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan No. ROP.SF.2A.2022.23, Anchorage.*

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## SIGNATURE PAGE

Project Title: Yentna River Chinook Salmon Sampling and Lake Creek Chinook Salmon Sonar Assessment, 2022

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Division, Region and Area: Sport Fish, Region II, Palmer

Project Nomenclature: SF-22133 SWG Susitna River Chinook Salmon Inriver Abundance

Period Covered: FY 2022–2023

Field Dates: May 1–July 31, 2022

Plan Type: Category III

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## ABSTRACT

This study will conduct a sonar count of the Yentna River drainage Chinook salmon (*Oncorhynchus tshawytscha*) run to Lake Creek and collect age data from the greater Yentna River run with fishwheels at river mile (RM) 6. Radio tags deployed at RM 6 will be used to estimate the proportion of the Yenta River run returning to Lake Creek. Data from this project will be incorporated into a run reconstruction model and spawner–recruit analysis to enable a better estimate of the historic run and escapement to the Yentna River.

Keywords: Chinook salmon, abundance, mark–recapture, Susitna River, PIT tag, dart tag, gillnet, fish wheel, sport harvest, genetic stock identification

## INTRODUCTION

### PURPOSE

In 2020, Chinook salmon fisheries assessment and management was changed in the Susitna River drainage from a system with aerial index escapement goals for individual rivers and creeks to broader-area stock-based escapement goals. These stocks, Talkeetna River, Eastside Susitna River, Deshka River, and Yentna River, each comprise 1 or more spawning tributaries in a defined geographic area. This scenario was made possible by a run reconstruction model and spawner recruit analysis that incorporates 40 years of data on these populations, mainly from aerial index surveys, weirs, creel surveys, and mark–recapture studies. Of the stocks considered in this model, the Yentna River stock has a paucity of data in relation to its size in comparison to the other stocks. This study will address this deficiency by adding a sonar count of the Chinook salmon run to Lake Creek and added age data from the greater Yentna River run, which is a major component of the spawner–recruit model used for developing Susitna River drainage escapement goals.

### BACKGROUND

In response to recent downturns in productivity and abundance of Chinook salmon (*Oncorhynchus tshawytscha*) stocks across Alaska and the social and economic hardships that have followed, the Alaska Department of Fish and Game (ADF&G) selected 12 indicator stocks to address knowledge gaps with studies of productivity, abundance, and other essential information needed to understand the root causes of these widespread declines (ADF&G Chinook Salmon Research Team 2013). The Susitna River was selected as one of these Chinook salmon indicator stocks, with estimation of the inriver run size in the mainstem Susitna and Yentna Rivers being recommended stock assessment projects.

Prior to the 2022 season, ADF&G established stock-based escapement goals for Susitna drainage Chinook salmon, including 3 stocks encompassing drainages into the mainstem Susitna River and 1 stock from the Yentna River drainage itself. An extensive run reconstruction and stock-recruit analysis was performed enabling the establishment of these goals, and estimation of escapements relative to these goals has continued using updated data in this model (Reimer and DeCovich 2020). Although the mainstem Susitna River stock abundances were estimated annually from 2013 through 2021 (e.g., DeCovich et al. 2020), the only data collected annually for the Yentna River stock have been the aerial index surveys of Lake Creek, the Talachulitna River, and Cache and Peters Creeks, which do not provide robust run size estimates.

The Yentna River is a large, remote river accessible only by boat or small aircraft. It supports multiple sport fisheries, the largest of which are on Lake Creek and the Talachulitna River (a tributary of the Skwentna River). The Kahilitna River drainage also supports spawning populations of Chinook salmon in its tributaries Cache Creek and Peters Creek, both of which previously had

escapement goals based on single annual aerial surveys. There are several smaller spawning populations of Chinook salmon in the remainder of the Yentna River drainage, including the Upper Yentna River and the Skwentna River, and most are only occasionally surveyed as budget allows.

Currently, aside from aerial index surveys of Lake Creek, the Talachulitna River, Cache Creek, and Peters Creek, the only data available for estimating Yentna River escapements is a mark–recapture project that was performed from 2014 to 2017, which provided robust run size estimates that continue to serve as a major component of the current model used to assess this stock. Although continuing the mark–recapture project would be ideal, it is too expensive to conduct within current budget constraints.

This project will address the data deficiency with a sonar estimate of the Yentna River Chinook salmon run at Lake Creek and sampling and radiotagging of Chinook salmon at Yentna RM 6 and will enhance our understanding of this vital wild Chinook salmon stock. The sonar at Lake Creek will provide a direct estimate of the run size for a major component of the Yenta stock, as opposed to the index provided by the aerial survey. The aerial survey count will continue to be conducted along with the sonar count, providing information about the observability of Chinook salmon in aerial counts. Several ancillary pieces of collected data will also help improve the stock assessment model. For example, the proportion of the Yentna River Chinook salmon spawning population that spawns in Lake Creek will be estimated using radio tags, and scales collected at this location will provide much needed age structure data that can be incorporated into the spawner recruit model instead of using an inferred age structure from data collected at the Deshka River weir in the mainstem Susitna River drainage.

## **OBJECTIVES**

### **PRIMARY OBJECTIVE**

- 1) Estimate the number of adult Chinook salmon that migrate past RM 4.5 of Lake Creek during June and July such that the seasonal estimate is within 10% of the true value 95% of the time.

### **SECONDARY OBJECTIVES**

- 2) Estimate age composition of all Chinook salmon in the mainstem Yentna River upstream of RM 6.
- 3) Document the number of radiotagged Chinook salmon  $\geq 500$  mm mid eye to tail fork length that putatively spawned within the Yenta River drainage, and the proportion of those that putatively spawned in Lake Creek both above and below the sonar.

## **METHODS**

### **STUDY DESIGN**

This project will utilize 2 locations, a tagging and age, sex, and length (ASL) sampling camp on the Lower Yentna River at RM 6 and a sonar camp at Lake Creek RM 4.5 that will count Chinook salmon returning to Lake Creek (Figure 1). Fish wheels will be used at RM 6 to capture fish for ASL sampling, and age will be determined from collected scales. Radio tags will be applied to 100 fish captured at RM 6, and the number of those tags that migrate to Lake Creek will be determined by a combination of fixed detection stations and receivers placed in a helicopter used for aerial surveys. The RM 4.5 Lake Creek sonar will be used to enumerate the entire run past that location.

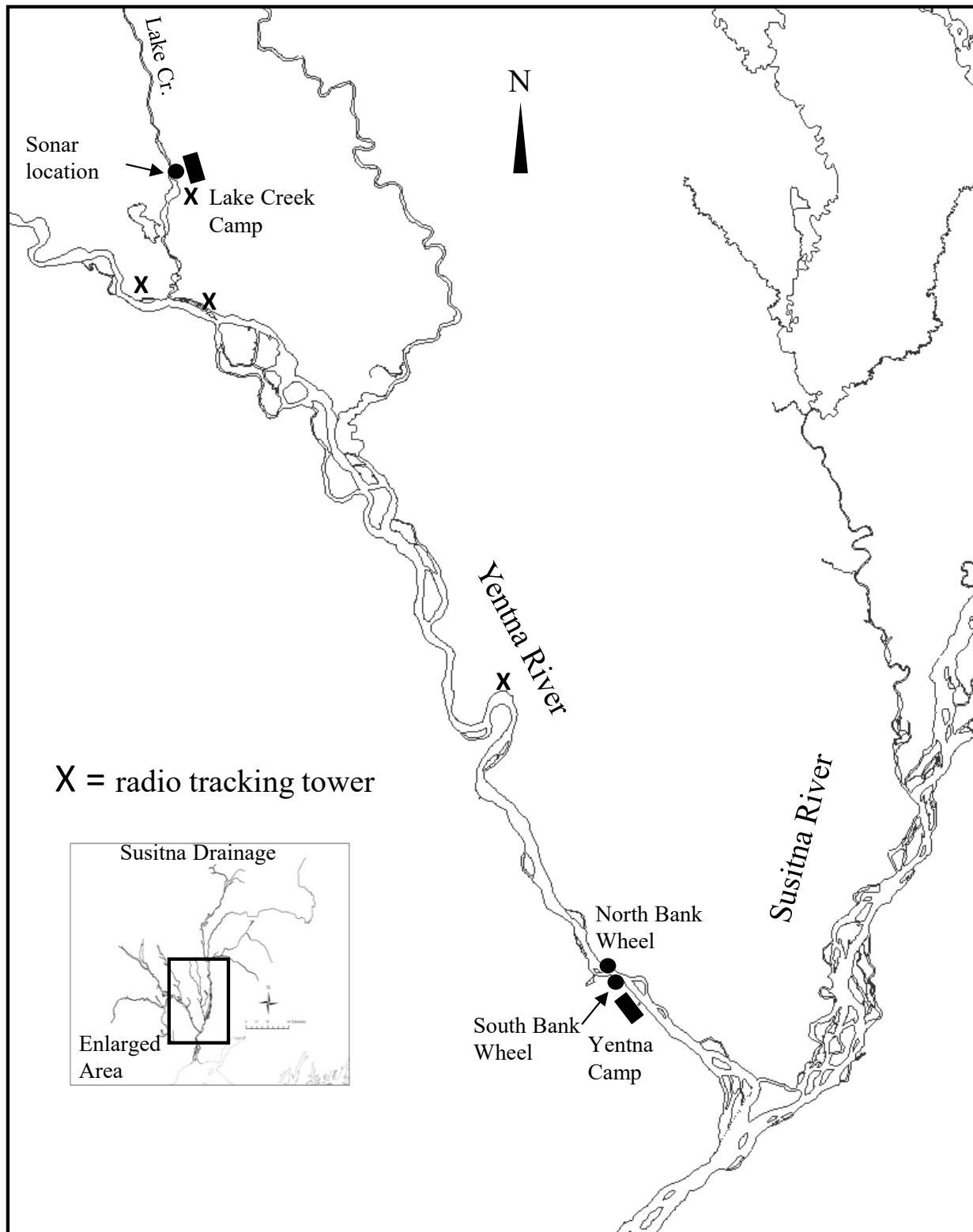


Figure 1.—Sampling design for the Yentna River sampling and Lake Creek sonar sites.

The Lake Creek sonar will be in the water from June 1 through July 30. The run timing of Chinook salmon through the lower section of Lake Creek is unknown. Information from local sport fishing lodges suggests that these dates will capture most of the run. If after the first year of sonar operations it is apparent that we missed the front or tail ends of the run during these dates, adjustments will be made to future projects. Other species present during this period are assumed to be mostly resident rainbow trout and Arctic grayling. Lake Creek sockeye salmon counts at Chelatna Lake, the headwaters of Lake Creek, suggest that the tail end of the Chinook run at RM 4.5 will coincide with the beginning of the sockeye salmon run (Robert DeCino, Alaska Department of Fish and Game, Division of Commercial Fisheries, unpublished data). Species apportionment of sonar counts is assumed not to be an issue at this time. This project is the first assessment ever done in lower Lake Creek, and it is anticipated we will learn how to refine our methods appropriately after this first year. The presence of sockeye salmon during Chinook salmon enumeration efforts will be monitored, and the shallow, clear water at the sonar site should enable easy monitoring. However, due to the swift flow and large boulders present throughout the creek, netting or other efforts are not considered feasible at this time.

Sonar estimates of Chinook salmon at Lake Creek will give a more robust estimate of escapement for the Yentna River stock and also be used to determine the proportion of the actual escapement counted by the aerial survey, what we call observability, which is an important parameter of the run reconstruction model used to assess the Yentna River stock.

#### **YENTNA RM 6 SITE DESCRIPTION**

A permanent camp is located at Yentna RM 6. There is a tool shed and tent platform for a WeatherPort shelter on site. Prior to the start of the field season, new tent platforms will be constructed, and the existing outhouse will be evaluated and replaced if necessary. Two fish wheels will be operated at this location, one on each bank. This camp and the location of the fishwheels have been used in the past (DeCovich et al. 2020) and are proven to be reliable.

#### **LAKE CREEK RM 4.5 SITE DESCRIPTION**

The Lake Creek RM 4.5 site (Figures 1 and 2) is located near the downriver end of an island (large gravel bar) at lat 61.9560, long -150.9080. The site has a main channel approximately 49 meters wide and a small back channel on the right bank (on the right side of the river when facing downstream; Figure 2). The back channel is very shallow and water flow is almost nonexistent, so no Chinook salmon should be able to pass upstream in the back channel. In this first year of the study, staff will monitor this channel daily for the presence of Chinook salmon, and a weir will be installed in the back channel if necessary to prevent Chinook salmon from passing unmonitored. The substrate at this site is composed of large rocks and some small to large boulders. The right bank (gravel bar side) has a very shallow, gradual slope extending approximately two-thirds of the way across the river with the slightly deeper thalweg running along the left bank (Figure 3). During a site visit in July 2021, no holding or milling fish were observed in this section of river.

Prior to the start of sonar operations, a camp will be constructed consisting of 3 platforms for sleeping tents, 1 platform for a WeatherPort shelter, and an outhouse. The camp will be located in a grove of cottonwood trees above the river's left bank (Figure 2), close enough to the sonar unit that the computer used to operate the unit will be housed in the WeatherPort shelter. Any trees that might fall on the tents in a windstorm will be felled before the start of the project.

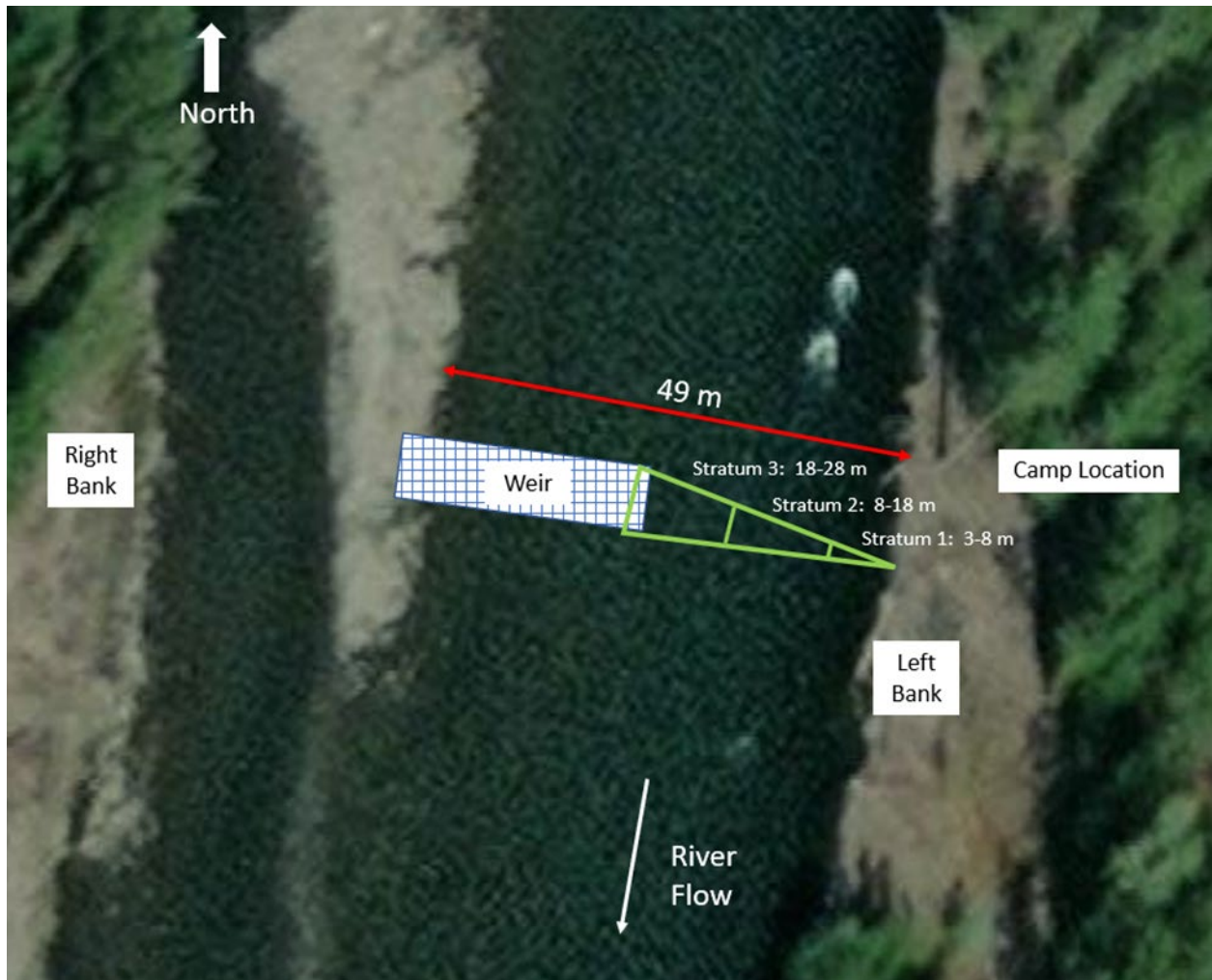


Figure 2.—Detailed image of the Lake Creek RM 4.5 sonar site depicted in Figure 1.

Source: Satellite image obtained from ADF&G Alaska Fish Resource Monitor interactive map (accessed April 2022).

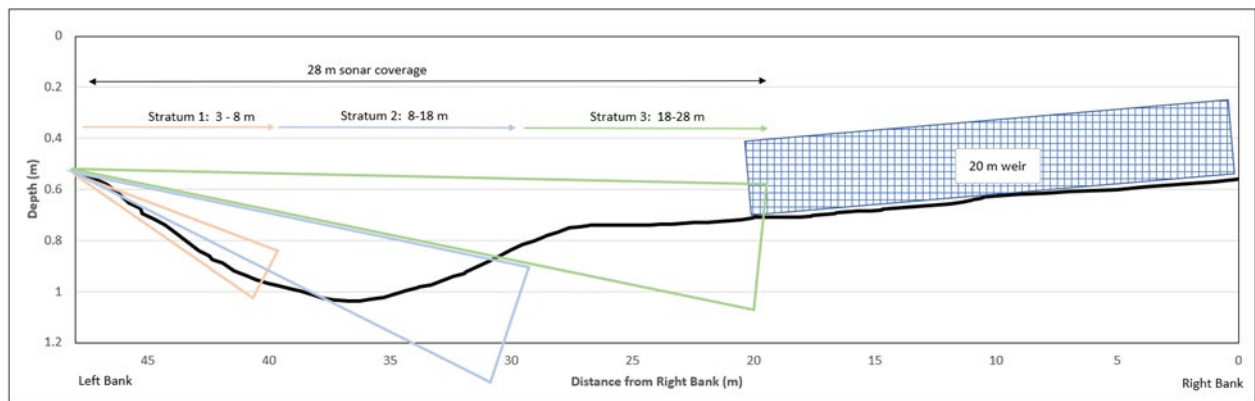


Figure 3.—Cross section of river bottom at the Lake Creek sonar site.

## DATA COLLECTION

### Yentna RM 6

#### *Fishwheel Operations*

Two fish wheels, one on each bank, will be operated every day of the season, except for flood events or when the wheels need to be removed or repaired. The fish wheels will be made of aluminum, with three 6 ft wide or two 4 ft wide baskets (depending on availability) webbed with knotless nylon 1.5-inch mesh netting (square measure). Captured fish will descend an aluminum basket chute to a fabric slide crossing above the float and exit into a live box. Live boxes will be 8 ft long, 2 ft wide, and 4 ft deep, with plywood sides with holes cut to allow water circulation. The configuration of the fish wheel axle, baskets, and floats make the fishing depth a maximum of 4.5 ft. The axle height will be adjusted so that the baskets sweep as close to the river bottom as possible. Fish wheels will be tied to the river bank and braced offshore with poles to position the wheels in sufficient current to make them spin. A picket weir with 1.5-inch gaps between pickets will be installed between shore and the fish wheel to direct migrating salmon towards the fish wheel baskets. Closed-cell foam padding will be placed where appropriate to prevent injuries as fish exit fish wheel basket chutes.

#### *Sampling*

Chinook salmon sampling will occur approximately 21 May to 30 June 2022. Sampling will begin when water levels and debris loads allow for safe operation of fish wheels and gillnets. The field crew will consist of 2 people working a 7.5 h shift, with the fishwheels operating for 6.5 h per day, and the remaining 1 h used for data organization. A meal break of 0.5 h will be scheduled in the middle of each shift. Each shift will start at 8:00 AM, and the first fish wheel to be lowered into the water will be alternated daily. After the first fish wheel is lowered, the second fish wheel will be lowered on the opposite bank. Once spinning, the crew will alternate visits to each wheel at the top and bottom of the hour. This schedule will enable each wheel to be checked and sampled hourly 6 times per day, with the remaining 1 hour for data organization and gear maintenance.

At each site, sampling and radiotagging data will be recorded on Rite-In-Rain data sheets and entered in Excel spreadsheets at camp. Fish wheel catch and effort data will be recorded on the “2022 Yentna RM 6 daily catch and effort” form (Appendix A1) and sampling and tagging data will be recorded on the “2022 Yentna RM 6 sampling and radiotagging” form (Appendix A2). The forms will be filled out with date, crew initials, total fish wheel operation time, shift, start and stop times, crew arrival and departure time, and the total number of Chinook salmon caught, sampled, and tagged. In addition, the total number of other species captured during the shift will be recorded.

#### **ASL Sampling**

For every Chinook salmon  $\geq 400$  mm and every fifth Chinook salmon  $< 400$  mm caught at each fish wheel, 4 scales will be taken from the preferred location on the left side of the body at a point on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin and 2 rows above the lateral line (Welanders 1940; Scarnecchia 1979; Appendix B1). If the preferred scales cannot be obtained, another scale will be taken from as close to the preferred scale as possible, always from the first or second row above the lateral line to capture the early life history portion of the age. If no scales are available in the preferred area on the left side of the fish, scales will be collected from the preferred area on the right side of the fish. If scales are not

obtainable from a given fish, that fish will not be sampled, and sampling will continue with the next available fish.

Chinook salmon scales will be mounted on gum cards and impressions made in cellulose acetate as described in Clutter and Whitesel (1956) and Scarnecchia (1979). Date, sampler name, and location will be recorded on the gum card. The impressions will be magnified and viewed on a microfiche reader, and the ages will be determined from the growth patterns of the circuli. Ages will be reported in European notation (Jearld 1983) and recorded in an ASL spreadsheet after the season is over.

Sampled fish will be measured from mid eye to tail fork (METF) to the nearest 0.5 cm. Sex will be determined by external physical characteristics, such as kype development or a protruding ovipositor. Length and sex will be recorded in waterproof notebooks while sampling and later transferred to the daily report form (Appendix A2). A hole will be punched through the dorsal portion of the caudal fin of each sampled fish as a secondary mark. All fish subsequently recaptured with this mark will be returned to the water immediately.

### **Genetics Sampling**

A 1½ cm (half-inch) piece of the axillary process will be removed from each radiotagged fish and for all other Chinook salmon sampled for ASL. The vial number of each sampled fish will be recorded on the sampling data sheet (Appendix A2) to ensure that future genotype data will be paired with ASL and radio tag data. Each sample will be placed in denatured ethanol in an individually labeled 2 ml vial (Appendix B2). All salmon samples and relevant collection data will be shipped to the ADF&G Division of Commercial Fisheries Gene Conservation Lab in Anchorage at the end of the season. All genetics sample processing, data storage, and data analysis will be the responsibility of the ADF&G Gene Conservation Lab.

### ***Radio Telemetry***

#### **Tagging**

Radio tags will be deployed in Chinook salmon  $\geq 500$  mm according to the schedule in Table 1. This schedule was developed during past studies and was shown to adequately sample in proportion to the actual run (DeCovich et al. 2020). Radio tags will be inserted through the esophagus and into the upper stomach using a 0.38 inch (outside diameter), 12-inch long plastic tube. The antenna of the radio transmitter will be threaded through the tube and pinched by hand at the end of the tube such that the radio transmitter is held tightly against the opposite end of the tube. A paper punch will be used to punch a hole in the dorsal portion of the caudal fin. All tagged fish will also be sampled for ASL and genetics according to the instructions above.

#### **Detection**

Radio receivers (ATS Model R4500C) at each stationary tracking site (Figure 1 and Table 2) will be visited and downloaded twice per month. Each record will contain the following fields in ASCII text format: year, Julian day, hour, minute, antenna, frequency, pulse code, signal strength, and duplicate counts. A laptop computer will be connected to the radio receiver with a serial cable and ATS software will be used to transfer the data file to the laptop. A logbook will be maintained at each station to note the date, staff, settings, and battery voltage for each visit. A checklist with radio receiver settings and the download steps will be at each site. Each downloaded file will be transferred to the Palmer local area network (LAN), uploaded to Docushare for ADF&G Region II (<http://docushare.sf.adfg.state.ak.us/dsweb/Homepage>) and eventually appended into an SQL telemetry database.

Table 1.–Radiotagging schedule for Chinook salmon at the Yentna River RM 6 fish wheels, 2022.

Date	North bank fish wheel	South bank fish wheel	Date	North bank fish wheel	South bank fish wheel
21 May	1	0	11 Jun	2	1
22 May	1	1	12 Jun	1	2
23 May	0	1	13 Jun	2	1
24 May	1	0	14 Jun	1	2
25 May	1	1	15 Jun	2	1
26 May	1	1	16 Jun	1	1
27 May	1	2	17 Jun	0	1
28 May	2	1	18 Jun	1	0
29 May	1	2	19 Jun	0	1
30 May	2	1	20 Jun	1	0
31 May	2	3	21 Jun	0	1
1 Jun	3	2	22 Jun	1	0
2 Jun	3	2	23 Jun	0	1
3 Jun	2	3	24 Jun	1	0
4 Jun	3	3	25 Jun	0	0
5 Jun	2	3	26 Jun	0	1
6 Jun	3	2	27 Jun	0	0
7 Jun	3	2	28 Jun	0	0
8 Jun	2	3	29 Jun	0	0
9 Jun	2	2	Total	37	37
10 Jun	1	2			

Table 2.–Location of radiotracking stations.

Site name	Latitude	Longitude
Yentna RM 18	61.73671	–150.69148
Lower Lake Creek Mouth	61.901653	–150.897832
Upper Lake Creek Mouth	61.9109	–151.9532
Lake Creek sonar	61.956	–150.908

Stations are positioned to determine the number of radiotagged Chinook salmon that spawned within the Yentna River drainage and the fraction of those fish that spawned in Lake Creek both above and below the sonar. Determining the location of radiotagged Chinook salmon within Lake Creek is necessary because our historical abundance data for Lake Creek are germane to the entire drainage and we need to be able to relate our sonar estimate of abundance to our historical abundance estimates.

The number of radiotagged Chinook salmon that spawned within the Yentna River drainage will be determined by a telemetry station positioned at Yentna RM 18. Past studies have shown that all spawning occurs upstream of RM 18 (DeCovich et al. 2020), therefore a tower at this location



should include only Chinook salmon that were successfully tagged and made substantial upstream migration to spawning destinations within the Yentna River drainage. Past radiotelemetry data from the Yentna River drainage relied heavily on aerial surveys, but we believe using a radio tower to determine migration past Yentna RM 18 should provide a criterion for determining spawning success of radiotagged Chinook salmon that is approximately equivalent to our historical data.

To determine the fraction of radiotagged Chinook salmon within Lake Creek both above and below the sonar, we plan to use 3 telemetry stations. Radiotagged salmon that spawn upstream of the Lake Creek sonar will be identified using a radio tower at the Lake Creek sonar site. To identify radiotagged Chinook salmon that spawn within Lake Creek downstream of the sonar site, we plan to use 2 radio towers, 1 approximately one-half mile above the mouth of Lake Creek and another on a gravel bar just below the mouth. Lake Creek is a very braided stream in the lower 4 miles, and it meets the Yentna River via 3 mouths. Placing a tower above the most upstream mouth and another below the most downstream mouth will “bracket” this area. If a fish passes the downstream tower but does not pass either the upstream tower or the tower at the RM 4.5 sonar site, we will consider this fish as having a final location somewhere in the lower 4.5 miles of Lake Creek. The final location of any fish that meet this criterion will be further examined with the aerial survey tracking.

Radiotelemetry data will be collected in conjunction with aerial Chinook salmon counts (Oslund 2016) in the Yentna River drainage. The purpose will be to verify the location of radiotagged fish with respect to stationary tracking data. Aerial surveys are conducted as a separate project, but the additional effort and expense of adding and operating tracking equipment will be minimal.

A single Yagi 4-element antenna will be mounted to the helicopter used for aerial salmon counts and connected to a telemetry receiver with a coaxial cable. An external GPS receiver will also be connected to the telemetry receiver to get the GPS coordinates of each location where detections are made. Receivers will scan for all deployed radio tag frequencies and record date, time, latitude, longitude, frequency, pulse code, mortality code, and signal strength any time it detects a radio tag. During each survey, a handheld GPS will be used to record a track of that day’s flight path.

At the end of each survey, the receiver and handheld GPS will be connected to a computer to download the data for that day. All files will be stored on the local network. Postseason analysis of the information collected during these surveys will be used to confirm locations of radiotagged Chinook salmon relative to area assignments made using fixed telemetry stations.

## **Lake Creek Sonar**

### ***Acoustic Sampling***

An adaptive resolution imaging sonar (ARIS) 1200 manufactured by Sound Metrics Corporation (SMC) will be deployed with a high-resolution lens on the left bank of Lake Creek RM 4.5 from June 1 through July 30. During a site visit in July 2021, an ARIS 1200 was deployed from each bank to verify image quality. On the shallow right bank, the bottom substrate displayed on the ARIS image appeared to fade between 18 and 23 meters in range, suggesting that fish could pass undetected at far range. In addition, multipath propagation from bottom backscatter (multiple reflections from the same object, such as a rock) was observed on this bank, likely amplified by the shallow water depth. In contrast, when the ARIS was deployed from the left bank, good images of the bottom substrate were observed throughout the range (from 3 to 45 meters) with no multipath issues, indicating this would be the better bank from which to deploy sonar. Because the river

width at the RM 4.5 site is about 20 m greater than the approximate 30 m effective range of the ARIS 1200 in high frequency mode (Miller et al. 2016), a fixed picket weir approximately 20 m in length will be deployed on the shallow right bank to deflect fish offshore toward the left bank and into the insonified zone (Figure 2). In addition, a short deflection weir (2–3 m in length) may be deployed on the left bank if necessary to force fish to pass offshore of the sonar and through the insonified zone. All weir pickets will be spaced 1.5 inches apart and held in place with aluminum frames. The frames will be held in place in the river with tripods constructed of galvanized square tubing.

The ARIS will operate at high frequency (1.2 MHz) to provide the resolution necessary for obtaining accurate length measurements at all ranges. Components of the ARIS 1200 system are listed in Table 3, and Miller et al. (2016) provides more detail on ARIS parameter settings. To ensure proper beam fit, a river bottom profile will be produced at the beginning of the season using a Hummingbird Helix-9-G3N digital depth finder equipped with GPS capabilities.

Table 3.—ARIS system components used for data collection.

System component	Description
Sonar	ARIS 1200
Lens assembly	High resolution lens with $\sim 3^\circ \times 15^\circ$ beam pattern
Remote pan and tilt	Sound Metrics AR2 rotator—controlled via ARIScope software
Data collection computer	Dell Precision 7560 laptop computers

ARIS data collection will be controlled by a computer housed in a WeatherPort shelter located on the left bank. A communication cable from the ARIS unit will feed directly into the ARIS Command Module and data collection computer. A battery bank, charged daily using a combination of solar panels and a generator, will power the equipment. The ARIS unit will be mounted on an SMC AR2 pan-and-tilt unit for remote aiming in the horizontal and vertical axes. The sonar and rotator unit will be deployed in the river using an aluminium H-style mount. In the horizontal plane, the sonar will be aimed perpendicular to the flow of the river current to maximize the probability of insonifying migrating salmon from a lateral aspect. In the vertical plane, the sonar will be aimed to insonify the near-bottom region of the river. Internal sensors in the ARIS units will provide measurements of compass heading, pitch, and roll as well as water temperature.

In designing ARIS, the manufacturers (SMC) separated the data collection (ARIScope) and data processing (ARISFish) software components. In addition to transmit frequency mentioned above, ARIScope has several data collection parameters that are user selectable including frame rate, window length, sample period, transmit pulse width, focus, transmit power level, and receiver gain. The maximum achievable frame rate (a function of stratum end range and sample period) will be used for each stratum. Frame rate for each stratum will be arrived at empirically by first fixing the parameters for start and end ranges and sample period for each stratum and then finding the maximum achievable frame rate. Window length will vary by stratum and is determined by the start and end range (in meters) of the stratum being sampled. Based on information gathered during the July 2021 site visit, we anticipate there will be 3 range strata (nearshore [3–8 m], middle [8–18 m], and offshore [18–28 m]). In combination with transmit pulse width, sample period (or equivalently, detail) controls the downrange resolution for the image. All data will be collected at

a sample period of 10  $\mu$ s (microseconds; approximately 670 samples/beam for the 3–8 m stratum and 1,340 samples/beam for the 8–18 m stratum and the 18–28 m stratum). The 10  $\mu$ s resolution is a standard used by other sonar projects that measure fish lengths from ARIS images (Key et al. 2019; Miller et al. 2020) and provides an adequate balance between the accuracy of AL measurements and the amount of storage space required for processing and archiving data. Transmit pulse width will vary by stratum. As the insonified range increases, longer transmit pulse widths are generally required for sufficient power to achieve the greater range. At ranges beyond 10 m, the transmit pulse width will be set to “Auto” or will be manually set to ensure the transmit pulse width is long enough to get 2 samples within the transmit pulse as recommended by the manufacturer (Bill Hanot, personal communication, Sound Metrics Corporation, Seattle, WA). At ranges less than 10 m, transmit pulse width will be set long enough to get 1 sample within the transmit pulse (sample period plus 2 microseconds, also recommended by the manufacturer). Transmit level (transmit power) will be set to maximum for each stratum but receiver gain will vary by stratum up to the maximum setting of 24 dB. Finally, the autofocus feature will be enabled for all data collection so that the sonar automatically sets the lens focus to the midrange of the selected range window. Initial data collection parameters and any changes made to these parameters throughout the season will be recorded on parameter settings field data sheet (Appendix C1).

A systematic sample design (Cochran 1977) will be used to sequentially sample discrete range strata (“range windows”) for a total of 20 minutes per hour for each stratum. The ARIS can be programmed to automatically sample each range stratum using ARIScope. Dividing the total range to be insonified into shorter range strata allows the aim of the sonar beam to be optimized for sampling a given river section (i.e., generally the aim must be raised in the vertical dimension as sections farther from shore are sampled), and the reduced window size makes it easier to count fish throughout the range at high passage rates. Multiple range strata also allow data at different ranges to be collected at different frequencies to optimize image resolution. The ARIS will be programmed to sample three 20-minute range strata per hour (Stratum 1 [3–8 m] from 00:00 to 00:20, Stratum 2 [8–18 m] from 00:20 to 00:40, and Stratum 3 [18–28 m] from 00:40 to 00:00) and will operate 24 hours per day, 7 days per week.

### ***Remote Access to Sonar Site***

The regional sonar biologist will visit the site at the beginning of the season to assist with ARIS deployment and to train the site crew on how to monitor data collection and adjust data collection parameters and the sonar aim when necessary. Because the crew will likely be new to the use of sonar, the project biologist will visit the site regularly throughout the season to monitor data collection. In addition, a system to remotely access the data collection computers will be used so the regional sonar biologist can monitor the ARIS aim and data collection parameters and instruct the project biologist or crew on necessary aim adjustments and parameter changes. The data collection computer will be equipped with wireless internet service through a Verizon Jetpack MiFi 8800L (providing 4G LTE service) and will be accessed remotely using a GoToMyPC account.

## **DATA REDUCTION**

### **Yentna RM 6**

All data collected during tagging (Appendices A1 and A2) will be entered into Excel spreadsheets as they become available inseason and then consolidated into 1 master Excel workbook file

(Master\_Yentna\_2022\_Chinook\_ASJ\_Telemetry\_mm\_dd\_yy.xlsx) with separate worksheets for each data type (e.g., tagging, detection, fishing effort, etc.), stored in a dedicated subdirectory on the Palmer ADF&G LAN, and uploaded to Docushare at the ADF&G Region II office (<http://docushare.sf.adfg.state.ak.us/dsweb/HomePage>). A documentation spreadsheet will also be incorporated into the workbook that describes the variables in each sheet. Only the project leader (N. DeCovich) will have editing rights to the master workbook. All data files (.csv format) that are used in analyses by the R software package (R Development Core Team 2011) will be directly created from the latest master Excel file. Raw data files downloaded from ATS radio receivers or loggers and GPS instruments will be imported into an SQL Server telemetry project database that contains all aerial and station telemetry and fish tag data from 2006 through present. Database reports will be generated throughout the season to track progress. Queries for standard data analysis (i.e., tables and figures for reports) will be available to project personnel for data retrieval. Custom queries will be written upon request for dissemination of data to biologists and biometricians.

The SQL database and master Excel file will serve as the basis for all data analysis required to achieve the study objectives. After all data are edited and analyzed, a final copy of the database (in comma-delimited ASCII format), master Excel workbook, and R analysis code will be emailed, along with a data map, to Research and Technical Services (RTS) in the Anchorage ADF&G office for archiving on the SF intranet site.

## **Lake Creek Sonar**

ARIScope will be set to automatically record video files to a 2 TB external hard drive. Each day, hourly files (24 files per range stratum for a total of 72 files per day) will be backed up to 2 additional 2 TB external hard drives:

- 1) One backup hard drive will be kept at the sonar site and used by field staff to manually count all fish images from an echogram display using ARISFish V2.8 software. Electronic echograms provide a system to manually count, track, and size individual fish. Detailed instructions for counting fish images using echograms are given in Appendix C2. The field crew will record hourly raw upstream and downstream fish counts onto an ARIS count form and then transcribe counts into an Excel spreadsheet.
- 2) The second backup hard drive will be transported as feasible to the Palmer ADF&G office, along with a copy of the Excel spreadsheet, where the project biologist or other staff will use ARISFish to conduct counts of fish images and collect manual ARIS length (AL) measurements (if necessary) as described in Appendix C3 using copies of the same 20-minute data files that were used by the field crew to count fish images at the site. Field crew counts will then be compared to counts conducted in the office. Counts conducted in the office will be used to produce postseason Chinook salmon passage estimates as described below. The office counts will be considered final in this year one. In future years the field count may be considered preliminary if daily counts are released to ADF&G staff or the public, with a final postseason quality control check.

To avoid the problem of counting the same fish in multiple spatial strata, which would create a positive bias in the passage estimates, fish that are counted or measured will be subjected to a “centerline rule” (Appendix C3). Only those fish that cross the longitudinal central axis of the

ARIS video image will be candidates for measuring. Fish that do not cross the centerline will be ignored.

In 2022, the first year of this study, if appreciable numbers of fish other than Chinook salmon are found to be present during project operation dates, we will conduct postseason ARIS length (AL) measurements of all fish images greater than or equal to 30 cm. The 30 cm length will be used as a starting point and adjusted accordingly. We may then use AL measurements to differentiate large Chinook salmon from smaller Chinook salmon and other species using methods similar to those used by Key et al. (2019) and Miller et al. (2020). The experience we gain during this first season will help guide future decisions on the need to collect AL measurements and the possible use of length strata to differentiate large Chinook salmon from smaller Chinook salmon and other species.

## DATA ANALYSIS

Data collected during this project will be analyzed using a drainagewide stock assessment model for Susitna River Chinook salmon (Reimer and DeCovich 2020). Individual precision objectives were not identified for the 2022 season, although the planned data collections will contribute to filling out some of the least robust parts of the existing stock assessment dataset and will not only improve the precision of Chinook salmon stock assessments in the Yentna River drainage but also reduce the bias associated with the estimates. In future years it should be possible to demonstrate approximate precision gains associated with adding these data to the stock assessment model and to refine data collection to maximize precision gains.

### Yentna RM 6

#### *ASL Sampling*

Age will be determined from the scales collected from each fish, and the age composition of the entire sample set will be considered representative of the age composition of the run of Chinook salmon past RM 6. The age proportions of salmon captured in the fishwheel will be estimated as follows:

$$\hat{p}_z = \frac{n_z}{n} \quad (1)$$

where  $\hat{p}_z$  is the estimated proportion of salmon captured in the fishwheel from age category  $z$ ,  $n_z$  equals the number of fish sampled that were classified as age category  $z$ , and  $n$  equals the number of salmon sampled for age determination.

The sampling variance of  $\hat{p}_z$  will be calculated by

$$\text{var}[\hat{p}_z] = \frac{\hat{p}_z(1 - \hat{p}_z)}{n - 1} \quad (2)$$

#### *Radio Telemetry*

Radiotagging data will be used to estimate the proportion of the spawning population that spawned in Lake Creek:

$$\hat{p}_{Lake} = R_{Lake}/R \quad (3)$$

where  $\hat{p}_{Lake}$  is the estimated proportion of salmon spawning in Lake Creek,  $R$  is the number of radiotagged fish that travelled to a spawning area, and  $R_{Lake}$  is the number of fish from  $R$  that travelled to Lake Creek.

### Lake Creek Sonar

The ARIS system will be scheduled to operate 20 minutes per hour for each spatial stratum, 24 hours per day. There will be 3 spatial strata (approximately 3–8 m, 8–18 m, and 18–28 m) sampled. The number of fish  $y$  that satisfy criterion X (e.g., fish that migrated in an upstream direction) during day  $i$  will be estimated as follows:

$$\hat{y}_i = \sum_s \hat{y}_{is} \quad (4)$$

where  $\hat{y}_{is}$  is net fish passage in stratum  $s$  during day  $i$ , which will be estimated as

$$\hat{y}_{is} = \frac{24}{h_{is}} \sum_{j=1}^{h_{is}} \hat{y}_{ijs} \quad (5)$$

where  $h_{is}$  is the number of hours during which fish passage is estimated for stratum  $s$  during day  $i$ , and  $\hat{y}_{ijs}$  is hourly fish passage for stratum  $s$  during hour  $j$  of day  $i$ , which will be estimated as

$$\hat{y}_{ijs} = \frac{60}{m_{ijs}} c_{ijs} \quad (6)$$

where  $m_{ijs}$  is the number of minutes (usually 20) sampled for stratum  $s$  during hour  $j$  of day  $i$ , and  $c_{ijs}$  is the number of fish satisfying criterion X (e.g., upstream direction of travel) in stratum  $s$  during hour  $j$  of day  $i$ .

The variance of the daily estimates of  $y$  due to systematic sampling in time will be approximated (successive difference model<sup>1</sup>; Wolter 1985) with adjustments for missing data as follows:

$$\hat{V}[\hat{y}_i] \cong 24^2 (1-f) \frac{\sum_{j=2}^{24} \phi_{ij} \phi_{i(j-1)} (\hat{y}_{ij} - \hat{y}_{i(j-1)})^2}{2 \sum_{j=1}^{24} \phi_{ij} \sum_{j=2}^{24} \phi_{ij} \phi_{i(j-1)}} \quad (7)$$

where  $f$  is the sampling fraction (temporal sampling fraction, usually 0.17),  $\phi_{ij}$  is 1 if  $\hat{y}_{ij}$  exists for hour  $j$  of day  $i$ , or 0 if not, and

$$\hat{y}_{ij} = \sum_s \hat{y}_{ijs} \quad (8)$$

Downstream estimates of passage will be obtained by changing the criterion X for fish counts  $c_{ijs}$  in Equation 3 to “downstream direction of travel.” Estimates of daily net upstream passage will be obtained by calculating separate estimates of upstream and downstream passage (Equations 1–3) and subtracting the downstream estimate from the upstream estimate. The estimated variance of

<sup>1</sup> This is an assessment of the uncertainty due to subsampling (counting fish for 20 minutes per hour and expanding). The formulation in Equation 7 is conservative in the sense that it has been shown to overestimate the true uncertainty when applied to salmon passage data (Reynolds et al. 2007; Xie and Martens 2014).

net upstream daily passage will be the sum of the upstream and downstream variances. Several sonar projects in southcentral Alaska have satisfied our expected precision goals with this study design and data analysis.

## SCHEDULE AND DELIVERABLES

Dates	Activity
April 15–May 15	Finalize operational plan and prepare field supplies
May 16–20	Install Yentna RM 6 camp
May 21–June 30	Yentna RM 6 sampling and tagging
May 23–31	Construct Lake Creek sonar camp
June 1–July 31	Lake Creek sonar operation
July 20–August 5	Aerial survey flights
September 1–January 31	Data analysis and report writing of FDS report

## RESPONSIBILITIES

*Nick DeCovich, Fishery Biologist III*

Duties: Supervise all aspects of project (excluding data analysis): planning, budget, data collection, and reporting. Lead author on operational plan and report.

*James Miller, Fishery Biologist III*

Duties: Advise on all aspects of sonar operation, including periodic checks of sonar unit outputs during the field season. Coauthor on report.

*Adam Reimer, Biometrician III*

Duties: Advise all portions of the biometrics including planning, sample sizes, statistical methods, and data analysis. Perform data analysis and produce final estimates.

*John Campbell, Fishery Biologist II*

Duties: Lead all radiotelemetry portions of the project and supervise the Yentna RM 6 sampling site. Coordinate data collection, data analysis, purchasing, reporting, crew training, radiotracking station setup and downloads. Assist with hiring and writing the operational plan. Coauthor on report.

*Steve Dotomain, Fishery Biologist I*

Duties: Supervise the Lake Creek sonar site and assist with planning, hiring, and training field staff, data collection, data analysis, supervision, and purchasing. Assist with writing the operational plan and final report.

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## **APPENDIX A: DATA SHEETS**

Appendix A1.–2022 Yentna RM 6 daily catch and effort form with example data.

LOCATION	DATE	GEAR	MINUTES	CHINOOK	COHO	CHUM	PINK	SOCKEYE	WHITEFISH	OTHER	FIELD_NOTES	EDITING_NOTES
Yentna RM 6	6/3/2018	FW1	720	17	0	0	0	1	0	1	1 LNS	
Yentna RM 6	6/3/2018	FW2	720	17	0	0	0	2	0	0		
Yentna RM 6	6/4/2018	FW1	745	41	0	0	0	1	0	1	1 HWF	
Yentna RM 6	6/4/2018	FW2	720	22	0	0	0	3	0	1	1 HWF	
Yentna RM 6	6/5/2018	FW1	720	27	0	0	0	2	0	2	2 LNS	
Yentna RM 6	6/5/2018	FW2	726	14	0	0	0	0	0	0		
Yentna RM 6	6/6/2018	FW1	720	32	0	0	0	4	0	3	3 LNS	

Appendix A2.–2022 Yentna RM6 sampling and radiotagging data sheet.

DATE \_\_\_\_\_, 2022

2022 YENTNA FISH WHEEL CATCH - EFFORT AND TAGGING

FW 1

FW 2

SAMPLERS: \_\_\_\_\_

Radio # Start \_\_\_\_\_ End \_\_\_\_\_

Fishwheel: Start: \_\_\_\_\_ Stop: \_\_\_\_\_ Start: \_\_\_\_\_ Stop: \_\_\_\_\_

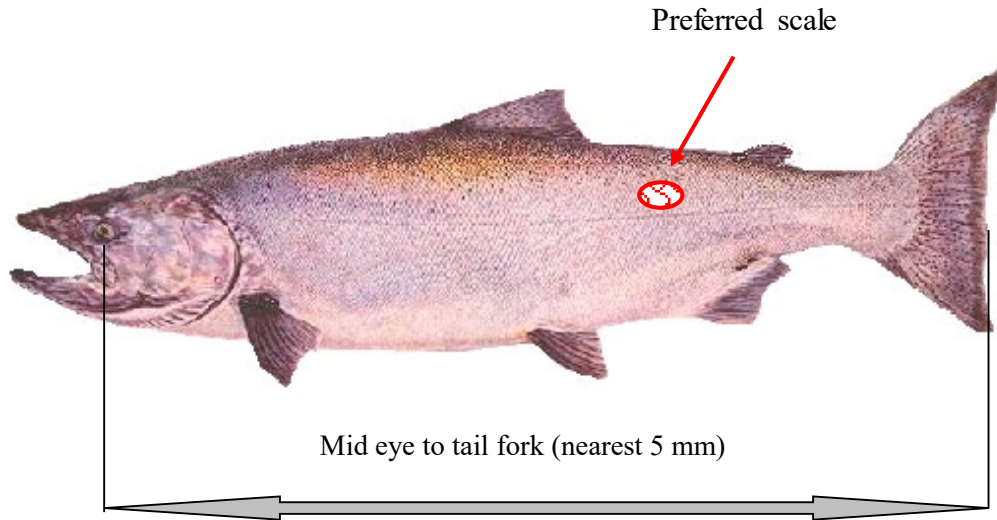
SPIN TIME: TOTAL MIN. \_\_\_\_\_

Scale Start Card \_\_\_\_\_ End Card \_\_\_\_\_

FISH CHECKS																				
	START TIME			END TIME			TOT MIN	MEF (mm)			Scale #	Sex	VIAL	RELEASE TIME			RECAP	OTHER SALMON	NON SALMON	COMMENT and/or Radio-Tag Frequency/Code/Number
1			.			.									.		YES			
2			.			.									.		YES			
3			.			.									.		YES			
4			.			.									.		YES			
5			.			.									.		YES			
6			.			.									.		YES			
7			.			.									.		YES			
8			.			.									.		YES			
9			.			.									.		YES			
10			.			.									.		YES			
11			.			.									.		YES			
12			.			.									.		YES			
13			.			.									.		YES			
14			.			.									.		YES			
15			.			.									.		YES			
16			.			.									.		YES			
17			.			.									.		YES			
18			.			.									.		YES			
19			.			.									.		YES			
20			.			.									.		YES			
Total																				

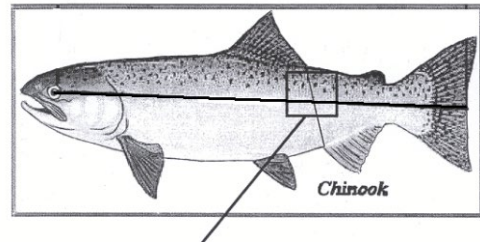


## **APPENDIX B: BIOLOGICAL SAMPLING PROCEDURES**



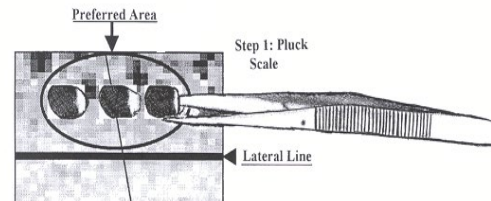
Length measurements are taken mid eye to tail for to the nearest 5 mm.

The preferred scale is located on the left side of the fish, 2 rows above the lateral line along a diagonal line from back (posterior) of the dorsal fin to the front (anterior) of the anal fin.

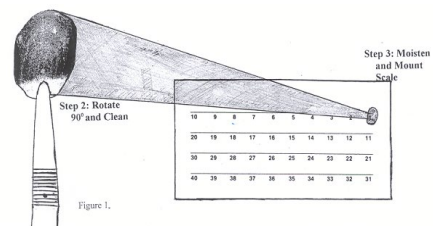


Pluck the "preferred scale" from the fish using forceps.

Pliers may be necessary to remove scales if the fish has been in freshwater for an extended period.



Remove all slime, grit, and skin from scale by moistening and rubbing between thumb and forefinger. Moisten the clean scale and mount it on the gummed card directly on top of the number "1."



A good scale has a well-rounded shape.

Hold scale up to light and examine for overall size, shape, regeneration, deformities, etc.

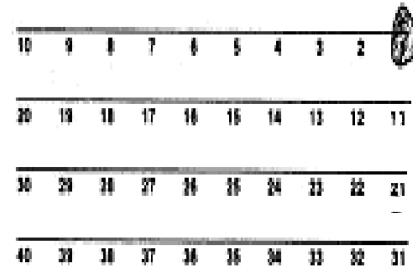


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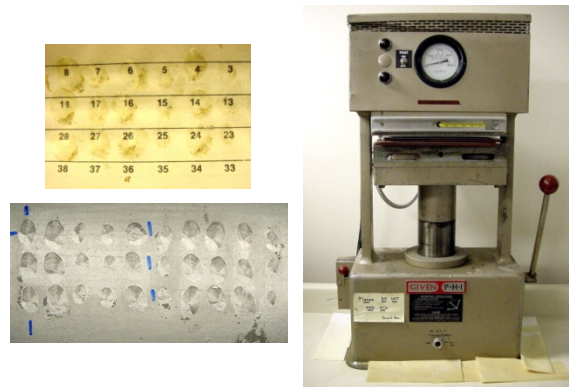
-continued-

When sampling Chinook salmon, take 3 scales per fish. Mount scale from fish number 1 over the numeral “1, 11, and 21.”

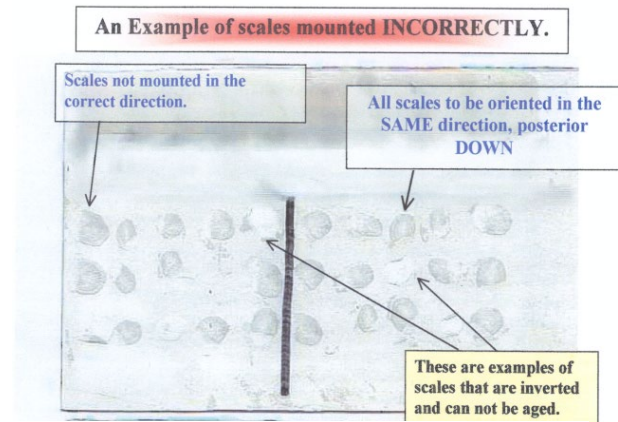
Continuing, to mount the one scale from fish number 2 over the numerals “2, 12, and 22” and so on...



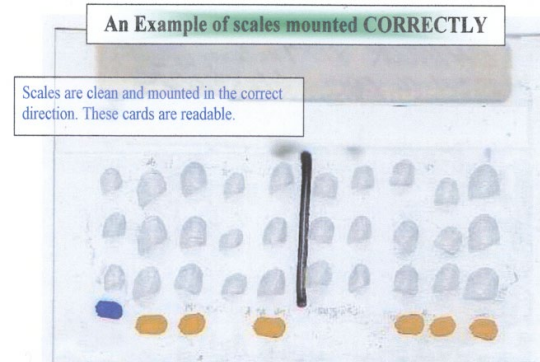
After the scales are mounted on the scale gum cards, they are pressed onto acetate.



Incorrect scale mounting



Correct scale mounting



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-continued-

Common problems encountered with inexperienced scale collectors include torn edges, inadequate scale cleaning, selecting regenerated or distorted scales, inverted scale mounting, and dirty gum cards. Common data recording errors include recording the scale number for sample, incorrect number of scale samples collected than recorded in data, and more than 1 fish with the same collection number. The following steps should help resolve these problems:

- 1) Experienced staff must take extra measures to ensure that less experienced staff become fully proficient at sampling before the first sampling event. Before the first sampling event, take a fish and slowly walk through the sampling routine with less experienced crew. Be sure to demonstrate steps 2–6.
- 2) Locate the lateral line and preferred scale sampling area.
- 3) Identify irregular scale patterns that are the result of regenerated scales.
- 4) Remove the scales in a manner that reduces torn edges.
- 5) Properly clean and mount scale samples.
- 6) Identify inversely mounted scales.

Minimize the handling of gum cards and keep them as dry as possible. Wet gum cards should be dried out slowly. Excessive heat when drying may cause the scale to become unglued from the gum card. After the gum cards are dry, they should be stored with wax paper between each gum card. Check the numbering between the Access database and the gum card.

### **Reading scale age**

Readers will review a test set of 50 scale samples from both Chinook and coho salmon. The test set contains scale samples from 2003 through 2007 for each species from various locations. Chinook salmon scale samples will include some fish of known ages (e.g., hatchery fish). Reader's test-set ages will be compared to previously determined age estimates and known ages. Ages that do not match will be reviewed and re-read. Once the reader ages are resolved, then the reader will begin with the collected samples from this season.

To estimate scale age, at least 1 scale per sample must have all of the following:

- 1) a clean focus
- 2) little or no regeneration in the freshwater growth
- 3) minimal tearing on the edge
- 4) clearly identified annuli through winter growth periods and crossing over of rings

If none of the scales from a sample contain all of these characteristics, then the age will be recorded as "NR" not readable. Samples with differing scale age estimates (i.e., scale 1 = 2; scale 2 = 2; scale 3 = 1) will be recorded as "NR."

A large number of scales have been collected from the projects. It is better to reject a fish from the samples than to use questionable scales.



## Appendix B2.–Genetic tissue sample collection procedures.

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### Non-lethal Sampling of Finfish Tissue for DNA Analysis

ADF&G Gene Conservation Lab, Anchorage

#### I. General Information

We use axillary process samples from individual fish to determine the genetic characteristics and profile of a particular run or stock of fish. This is a non-lethal method of collecting tissue samples from adult fish for genetic analysis. The most important thing to remember in collecting samples is that **only quality tissue samples give quality results**. If sampling from carcasses: tissues need to be as “fresh” and as cold as possible and recently moribund, do not sample from fungal fins.

Sample preservative: Ethanol (ETOH) preserves tissues for later DNA extraction without having to store frozen tissues. Avoid extended contact with skin.

#### II. Sample procedure:

1. Tissue type: Axillary process, clip axillary process from each fish (Appendix B3).
2. Data to record: Record each vial number to paired data information.
3. Prior to sampling, fill the tubes half way with ETOH from the squirt bottle. Fill only the tubes that you will use for a particular sampling period.
4. To avoid any excess water or fish slime in the vial, wipe the axillary process dry prior to sampling. Using the dog toe nail clipper or scissors, clip off axillary process (**1/2 -1” max**) to fit into the cryovial.
5. Place axillary process into ETOH. The tissue/ethanol ratio should be **slightly less than 1:3** to thoroughly soak the tissue in the buffer.
6. Top up tubes with ETOH and screw cap on securely. Invert tube twice to mix ETOH and tissue. Periodically, wipe the dog toe nail clippers or scissor blade so not to cross contaminate samples.
7. Discard remaining ethanol from the 500ml bottle before returning samples. **Tissue samples must remain in 2ml ethanol** after sampling. HAZ-MAT paperwork will be required for return shipment. Store vials containing tissues at cool or room temperature, away from heat in the white sample boxes provided. In the field: keep samples out of direct sun, rain and store capped vials in a dry, cool location. Freezing not required.

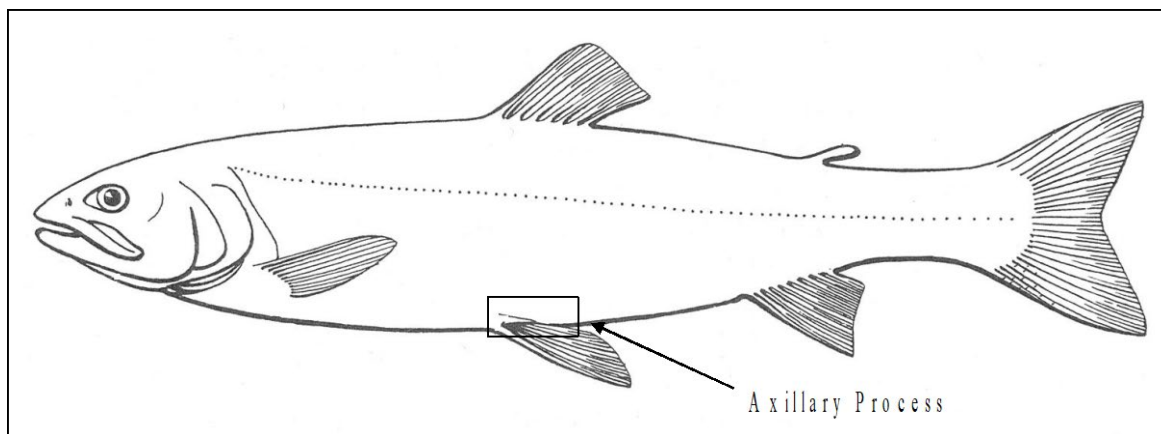
#### III. Supplies included with sampling kit:

1. (1) – Dog toe nail clipper - used for cutting the axillary process
2. (1) – Scissors can be used to cut a portion axillary process – if clippers don’t work for your crew
3. Cryovial- a small (2ml) plastic vial, pre-labeled.
4. Caps – with or without gasket to prevent evaporation of ETOH.
5. Cryovial rack- white plastic rack with holes for holding cryovials while sampling
6. Ethanol (ETOH) – in (2) 500 ml plus (1) – 125 ml Nalgene bottle
7. Squirt bottle – to fill or “top off” each cryovial with ETOH
8. Paper towels – use to blot any excess water or fish slime off axillary process
9. Printout of sampling instructions
10. (3) – three pair of lab gloves (size large)
11. Laminated “return address” label

#### IV. Shipping: HAZMAT paperwork is required for return shipment of these samples and is included in the kit.

Ship samples to: ADF&G – Genetics  
333 Raspberry Road

Lab staff: 1-907-267-2247  
Judy Berger: 1-907-267-2175



Appendix B3.—Location of axillary process.

## **APPENDIX C: SONAR INSTRUCTIONS**

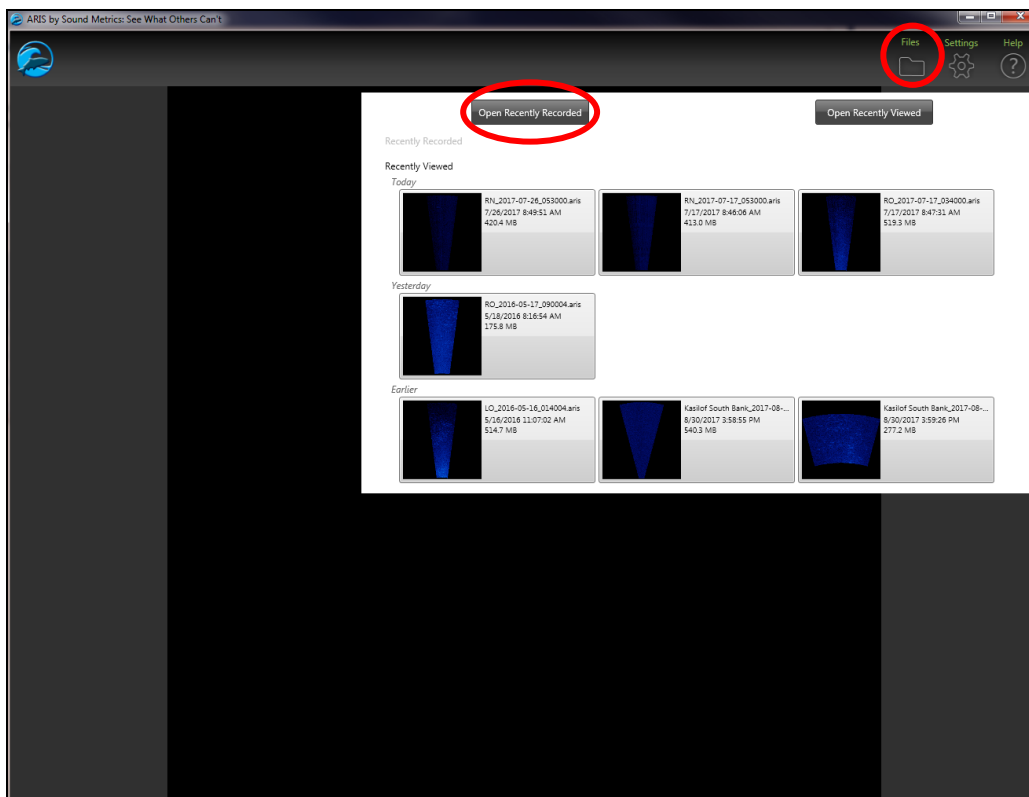
Appendix C1.-2022 Lake Creek sonar parameter settings field sheet.

Date	Stratum Number (1,2,3)	Sample Start Time (i.e :00, :20, :40, etc.)	Frame Rate	Start Range (m)	End Range (m)	Freq. (High, Low)	Transmit (Min/Max)	Gain	Pulse Width	Start Delay	Sample Period	Samples per Beam	AR2 Tilt	ARIS Pitch	ARIS Roll	ARIS Heading

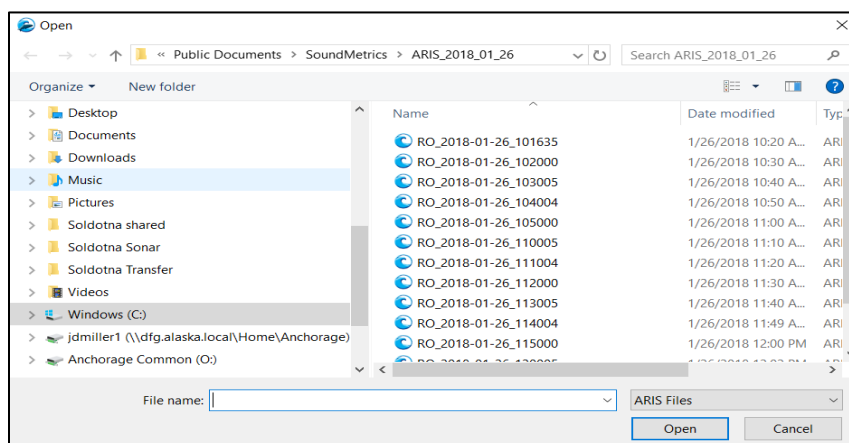
Appendix C2.—Instructions and settings for using echogram to count ARIS fish images with SMC ARISFish software Version 2.8.0.2295.

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- 1) Open ARISFish.
- 2) Maximize the ARISFish window to fit your computer screen.
- 3) Click on the “File” icon in upper right corner of window. This displays a list of recently recorded and recently opened .aris image files

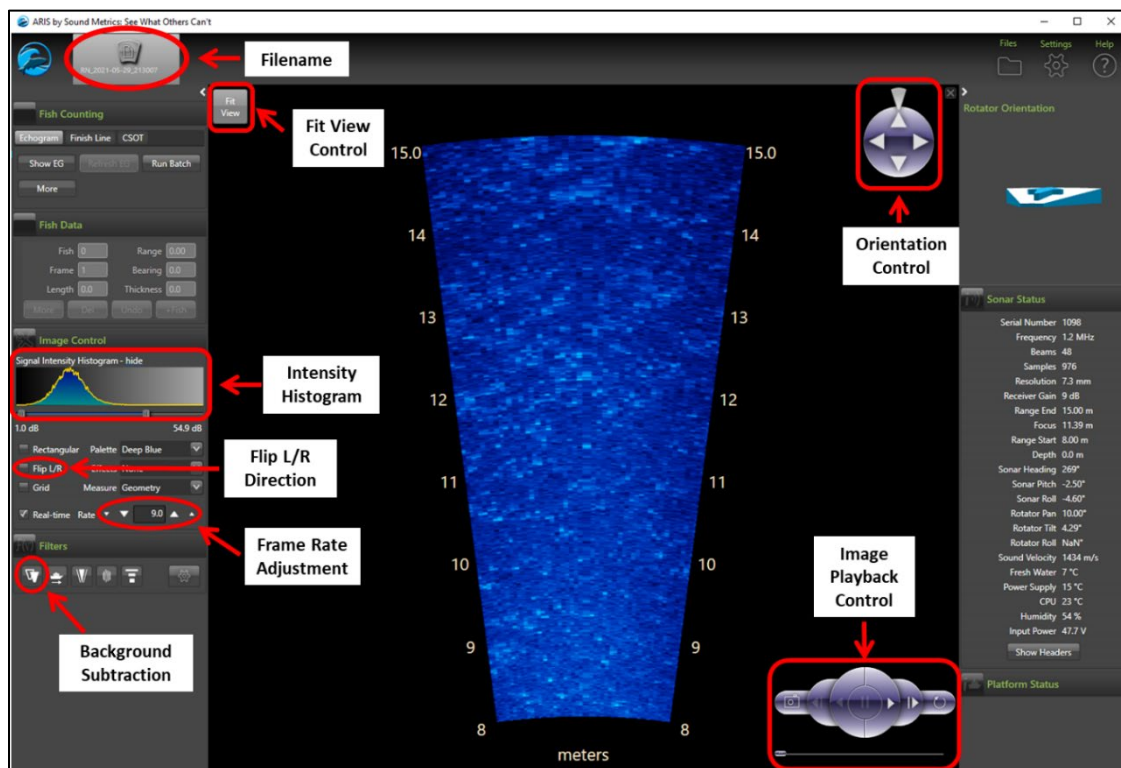


- 4) Click the **Open Recently Recorded** button to open a file browser to the last saved files.
- 5) Locate and open the file to process.



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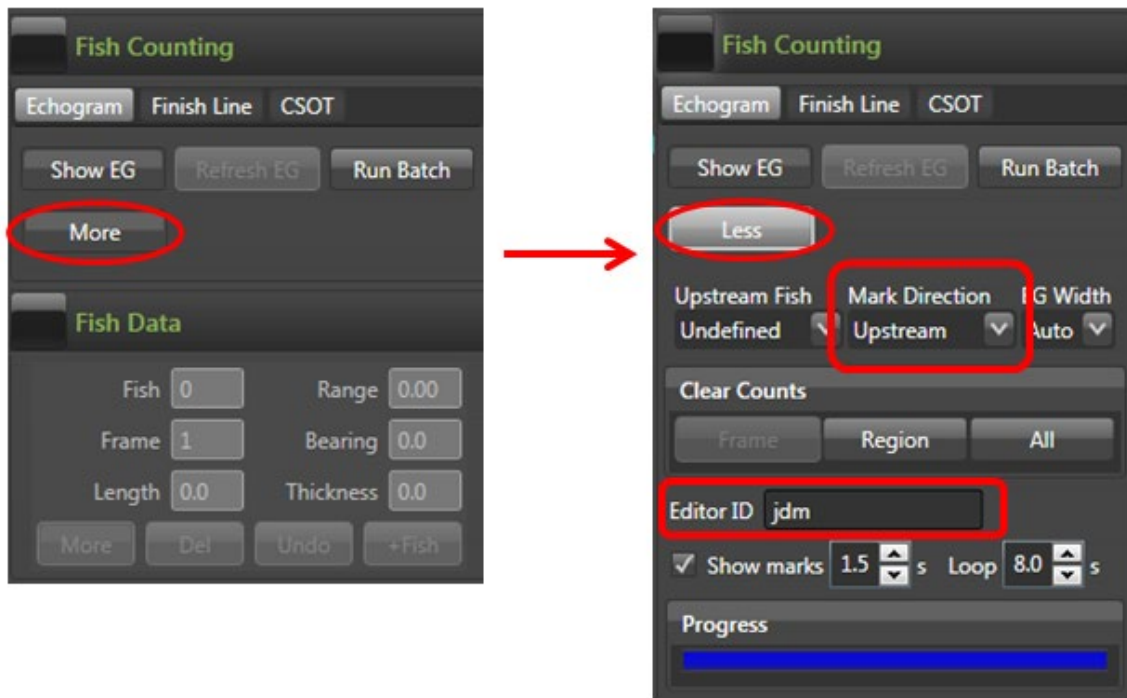
- 6) Ensure you have opened the correct file by checking the filename in the **Open File Icon** at the top left of the window.
- 7) **Signal Intensity Histogram** - Ensure that the slider buttons under the histogram are position such that the entire histogram lies between the two buttons. The sliders can be adjusted slightly to produce the best contrast between fish images and the background.
- 8) **Flip L/R** - If desired, can reverse the left and right sense of the displayed sonar image.
- 9) **Rate** (frame rate) - The recorded frame rate appears here when the file is first opened. Frame rate can be increased or decreased by using the triangular up/down buttons.
- 10) **Background Subtraction** icon - click this button to remove static background from the displayed sonar image. Use background subtraction if fish images are difficult to differentiate from the background.
- 11) **Fit View Control** - The sonar image can be zoomed in or out by using the zoom wheel on your mouse or by swiping two fingers on your laptop touchpad. The *Fit View* button will resize the view to show the entire image at its maximum size within the main display panel.
- 12) **Orientation Control** - Allows you to rotate the image orientation by either clicking one of the four triangular buttons (rotates 0, 90, 180, 270) or by clicking and dragging the "wedge" control on the outside of the circle to the desired percent rotation.
- 13) **Image Playback Control** - Can be used to play forward, play backward, advance single frame forward, advance single frame in reverse, and pause by clicking the appropriate button. Can also use slide at bottom to advance forward or backward to desired point in file.



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14) To process (count) a file using **Echogram** and/or **Video Image View**:

- a) On the **Fish Counting** panel (left side of the ARISFish window), ensure the **Echogram** tab is highlighted
- b) Click the **More** button under the **Echogram** tab - this will expand the panel to show echogram controls
- c) Ensure **Mark Direction** is set to "Upstream" using the drop-down arrow
- d) Enter your initials in the **Editor ID** box
- e) Then click the **Less** button to hide the echogram controls.



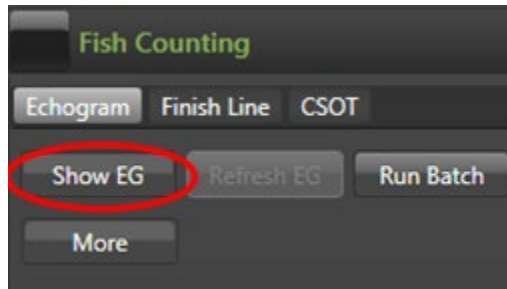
- f) On the **Filters** panel, click the **Background Subtraction** button to remove background from the image. This may take a few seconds.



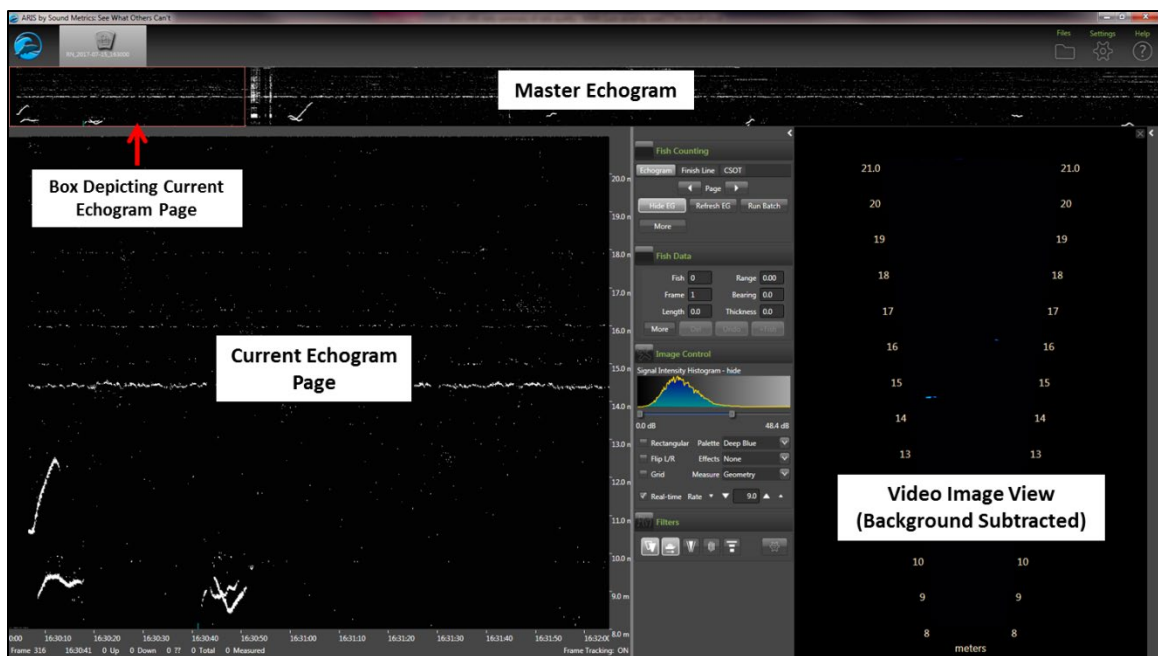
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- g) Once the background has been subtracted, click the **Show EG** button on the **Fish Counting Panel** to generate an echogram.



- h) It may take several seconds for ARISFish to generate the echogram. Once the echogram is generated, the screen will display the following three windows:
- a) Master Echogram - displays an echogram for the entire file
  - b) Current Echogram Page - displays a portion of the Master Echogram as depicted by a red box on the Master Echogram
  - c) Video Image View - displays the video image (in this case with background subtracted)

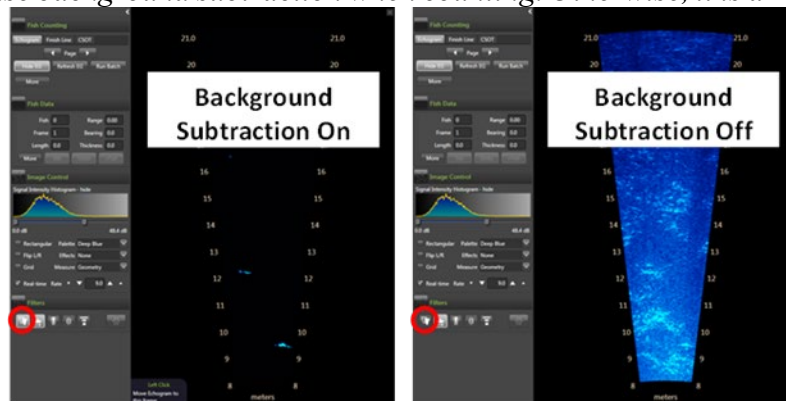


- i) Background subtraction in the **Video Image View** can be toggled on and off using the **Background Subtraction** icon on the **Filters** panel.

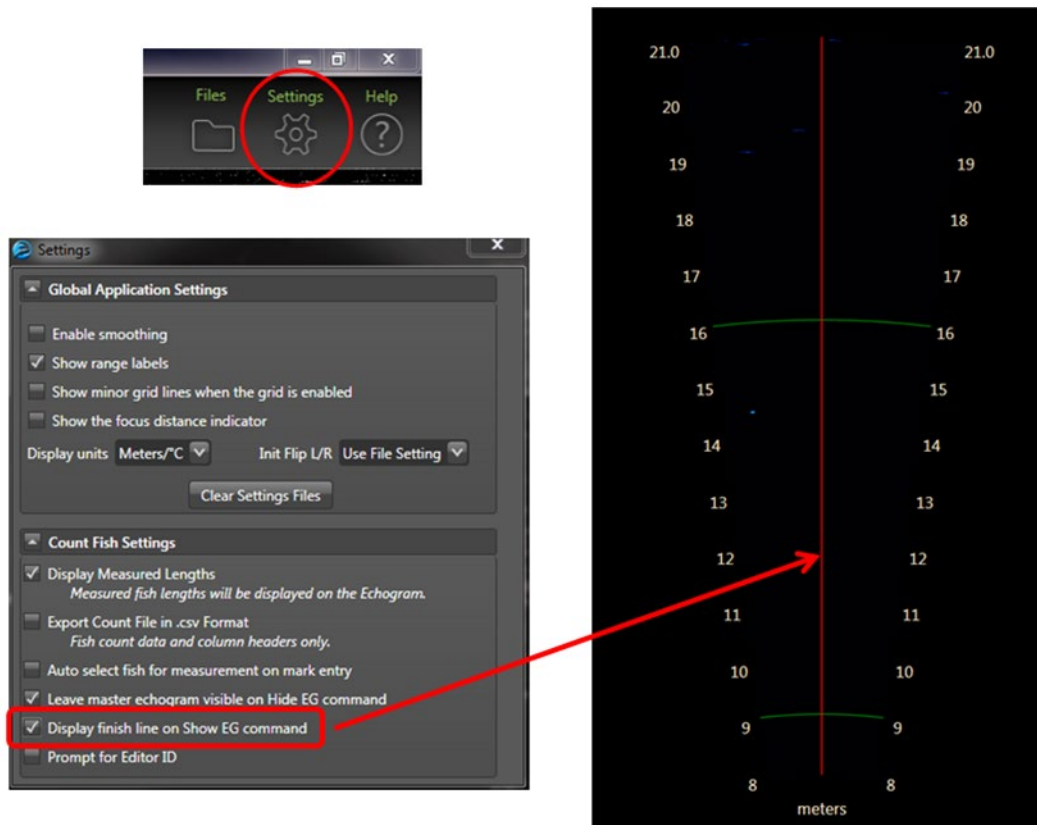
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***NOTE:** use of background subtraction when counting fish will depend on the contrast between fish images and the background. Further instruction may be provided by the Project Biologist as to whether or not to use background subtraction when counting. Otherwise, it is a matter of preference.*



- j) Turn on the Finish Line (centerline) in the **Video Image View**: open the Settings window by clicking on the **Settings** cog in the upper right of the ARISFish window then check *Display finish line on Show EG command*. The finish line will be referred to in these instructions as the centerline. The centerline will be used to determine valid fish images for counting purposes.

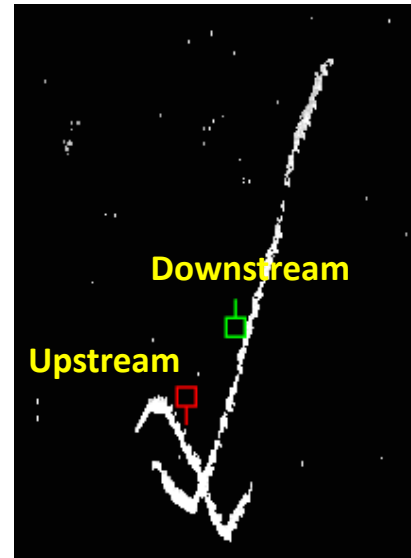


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k) Fish can be marked for counting in two ways:

a) Mark fish on **Echogram** (best for low fish passage rate)

- i. Move cursor from left to right over the fish traces on the **Current Echogram Page** to display the corresponding frame image in the **Video Image View**.
- ii. In this way, view each fish located on the **Current Echogram Page**, determine direction of travel, and whether the fish crosses the centerline on the **Video Image View**. Ignore fish that do not cross the centerline.
- iii. To mark a fish that crosses the centerline as upstream, simply left click on the fish trace in the Echogram window. This will display a **red** square ("head") with a "tail" segment underneath (indicating upstream swimming).
- iv. To mark a fish that crosses the centerline as downstream, hold the **Ctrl** key down while left clicking on the fish trace. This will display a **green** square ("head") with a "tail" segment above (indicating downstream swimming).
- v. To remove a mark, simply left click inside the red or green square.
- vi. Note that marks placed on the **Current Echogram Page** do not appear in the **Video Image View**.
- vii. Once finished marking all fish in the **Current Echogram Page** window, click in the **Master Echogram** (top of ARISFish window) to advance to the next section of the file. Be sure next section selected overlaps with pervious section to not miss any fish.

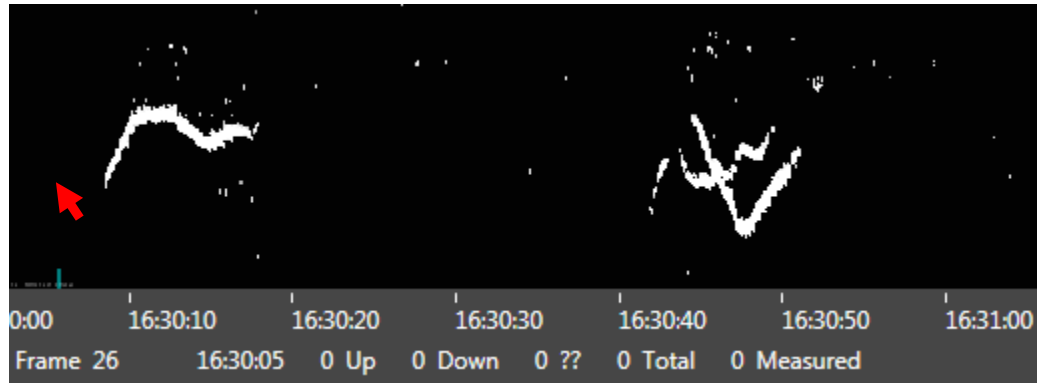


b) Mark fish on **Video Image View** (best for high fish passage rate)

- i. In the **Current Echogram Page** window, place mouse cursor where you want to start counting. Note the small blue line at the bottom of the window that marks the cursor location relative to frame number and time. *In the example below, the cursor (and therefore the corresponding blue line) is located at Frame 26, five seconds into the start of the file (16:30:05).*

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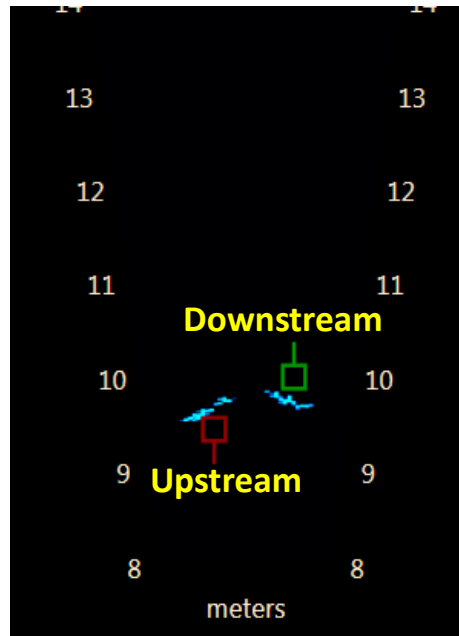
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- ii. Carefully slide the cursor down off the bottom of the echogram (into the gray border or beyond) and then slide it to the right to the **Video Image View**. Note that if you slide the cursor back up into the black echogram window, the blue "start" line will move to that location, so keep the cursor out of the black echogram window until it reaches the **Video Image View**.
- iii. Once the cursor reaches the **Video Image View**, press the space bar on the computer keyboard to play the video. *With the example above, the video will start playing at Frame 26, five seconds into the start of the file (16:30:05).*
- iv. Once the video is started in this way, it will continue to play through the end of the file.
- v. As the video plays in the **Video Image View** window, you can:
  - i. Pause and resume play - press the space bar on the computer keyboard.
  - ii. Reverse direction - press the right or left arrow keys on keyboard.
  - iii. Single-frame advance - press the right or left arrow keys on keyboard
- vi. As the video plays in the **Video Image View** window, mark fish as they cross the centerline passing upstream or downstream:
  - i. Upstream fish - left click on the fish image. This will display a **red** square ("head") with a "tail" segment underneath (indicating upstream swimming). This mark will appear both in the echogram and in the video.
  - ii. Downstream fish - hold the **Ctrl** key down while left clicking on the fish image. This will display a **green** square ("head") with a "tail" segment above (indicating downstream swimming).

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- iii. To remove a mark, simply left click inside the red or green square.
  - iv. All marks placed on the **Video Image View** also appear in the corresponding location on the **Current Echogram Page**.
  - v. If necessary, can slide cursor over the echogram while simultaneously watching video image to review marks and verify that fish were marked (counted) properly.
    - 1. If notice a missed fish, simply left click on the fish in the echogram or video to mark it.
    - 2. If notice a stray mark, simply click in the center of the mark (in echogram or video image) to delete the mark. While in video mode, the mark will fade in and out as the video is advanced past the marked frame, so be sure to click the brightest mark.
  - vi. To resume playing the video, simply place your cursor on the echogram where you want the video to resume, slide it down off the bottom of the echogram and over to the **Video Image View**, and click the spacebar.
  - vii. Continue to mark fish until the end of the file.
- 15) To process the next file:
- a) Click **Background Subtraction** button to turn background subtraction on.
  - b) Press *Alt+Right Arrow* or click the "File" icon in upper right corner of window to navigate to the next file using the file browser.

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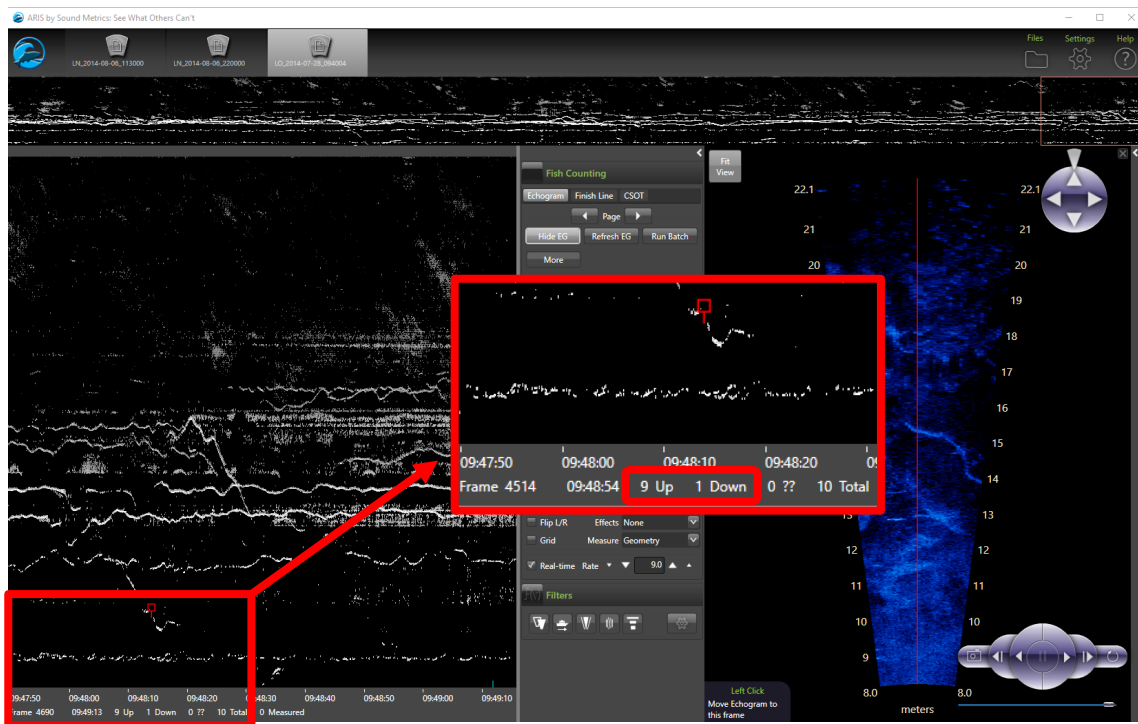
- c) Once new file is open in ARISFish, click **Background Subtraction** button to turn background subtraction off. Now ready to begin counting next file.

16) **Valid fish counts:**

- a) **Fish must cross centerline to be counted.**
- b) DO NOT count fish that are obviously holding
- c) When the file starts or ends, count only those fish that cross the centerline.
- d) Nearshore stratum - enumerate all fish that enter from the top of the screen (from offshore) and cross the centerline. Fish that enter from the bottom of the screen and cross the centerline should be counted (this is only valid for the nearshore stratum).
- e) Offshore stratum - do not count fish that fully exit through the bottom (nearshore end) of the beam prior to crossing the centerline. These fish will be considered nearshore fish even though they spend some time in the offshore zone.

17) When finished counting the file, note the total number of upstream and downstream counts in one of two ways:

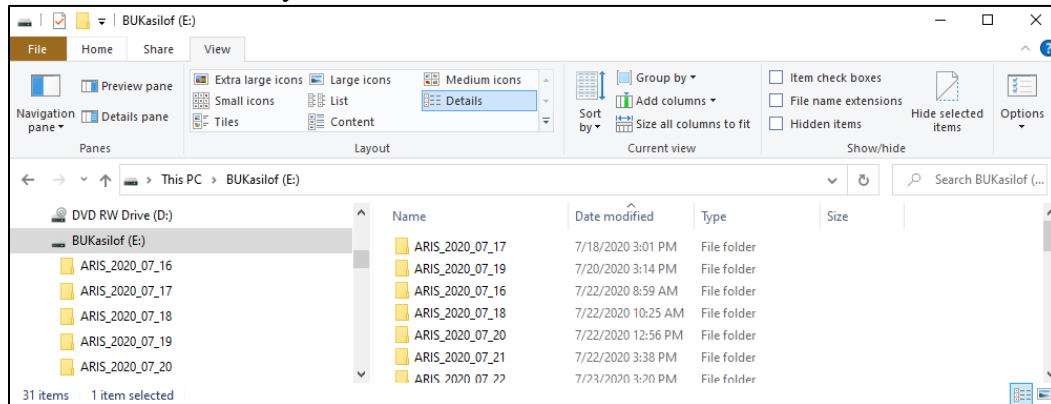
- a) ARISFish Echogram Fish Counter:
  - i. The total number of fish marked UP and DOWN can be found in the lower left of the echogram window.



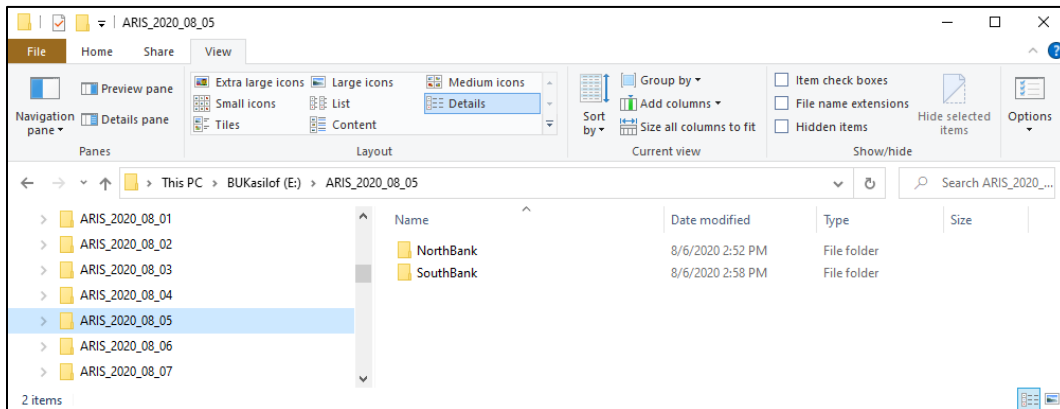
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b) ARISFish Text File Output:

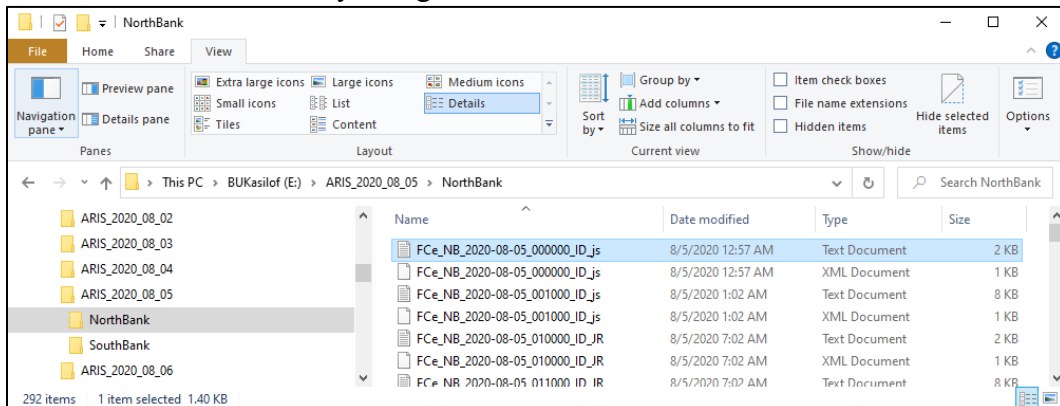
- i. Open Windows Explorer and navigate to the folder that contains the daily ARIS subfolders.



- ii. Open the ARIS subfolder that corresponds with the current date.



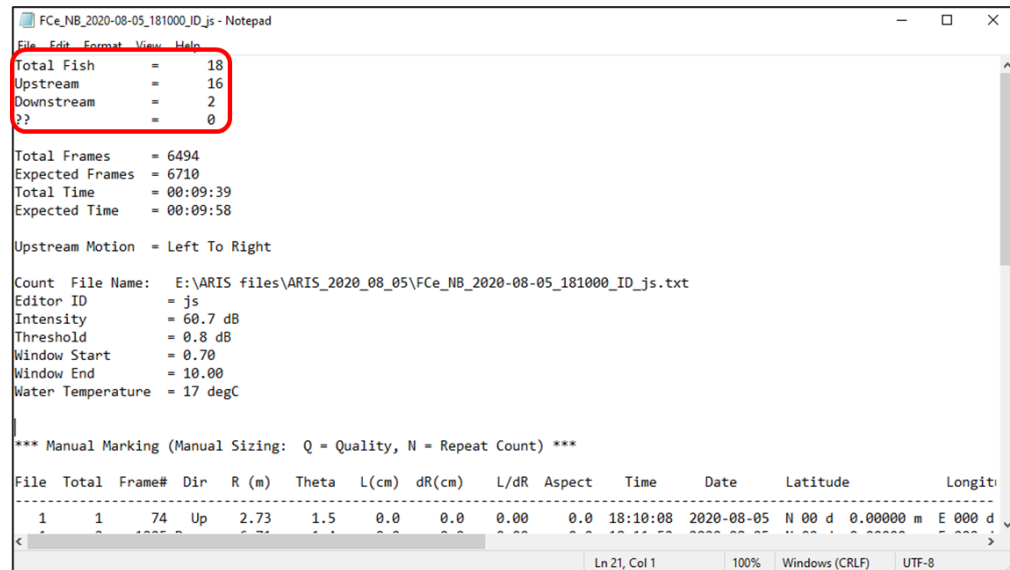
- iii. Then, if necessary, open the subfolder that corresponds to the stratum currently being measured.



- iv. Open the text document (\*.txt) that corresponds with the current hour (sample) measured.

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- v. The upstream, downstream, and total fish count for the given file can be found at the top of the text document.



```

Fce_NB_2020-08-05_181000_ID.js - Notepad
File Edit Format View Help
Total Fish      = 18
Upstream       = 16
Downstream     = 2
??            = 0

Total Frames    = 6494
Expected Frames = 6710
Total Time      = 00:09:39
Expected Time   = 00:09:58

Upstream Motion = Left To Right

Count File Name: E:\ARIS files\ARIS_2020_08_05\Fce_NB_2020-08-05_181000_ID.js.txt
Editor ID      = js
Intensity      = 60.7 dB
Threshold      = 0.8 dB
Window Start   = 0.70
Window End     = 10.00
Water Temperature = 17 degC

*** Manual Marking (Manual Sizing: Q = Quality, N = Repeat Count) ***

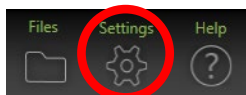
File Total Frame# Dir R (m) Theta L(cm) dR(cm) L/dR Aspect Time Date Latitude Longitude
-----
1 1 74 Up 2.73 1.5 0.0 0.0 0.00 0.0 18:10:08 2020-08-05 N 00 d 0.00000 m E 000 d

```

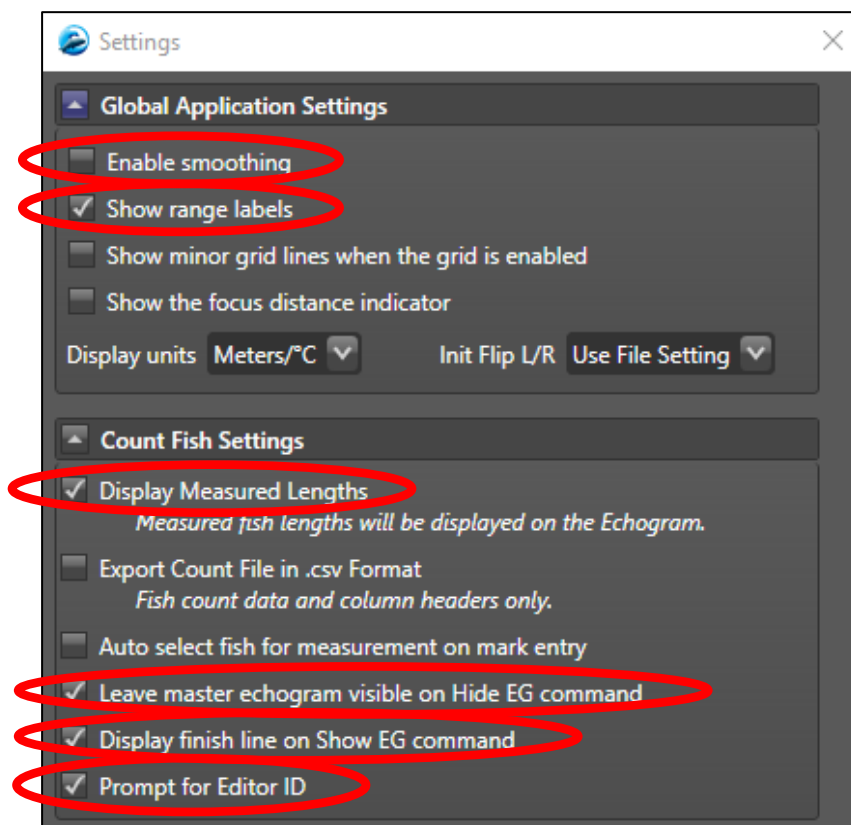
- vi. Record the number of upstream and downstream fish on the field datasheet or in an Excel spreadsheet as instructed (varies by project).
- vii. Close text file.

1) Set Global Application Settings and Count Fish Settings

- a) Open the ARISFish **Settings** menu by clicking on the **Settings** cog icon in the upper right-hand corner of the ARISFish window.



- b) In the Global Application Settings dropdown window, ensure that “Enable smoothing” is **unchecked**, and that “Show range labels” is **checked**.
- c) In the Count Fish Settings dropdown window, ensure that each of the following are **checked**:
- Display Measured Lengths
  - Leave master echogram visible on Hide EG command
  - Display finish line on Show EG command (for our purposes, we refer to the finish line as the “centerline.”)
  - Prompt for Editor ID



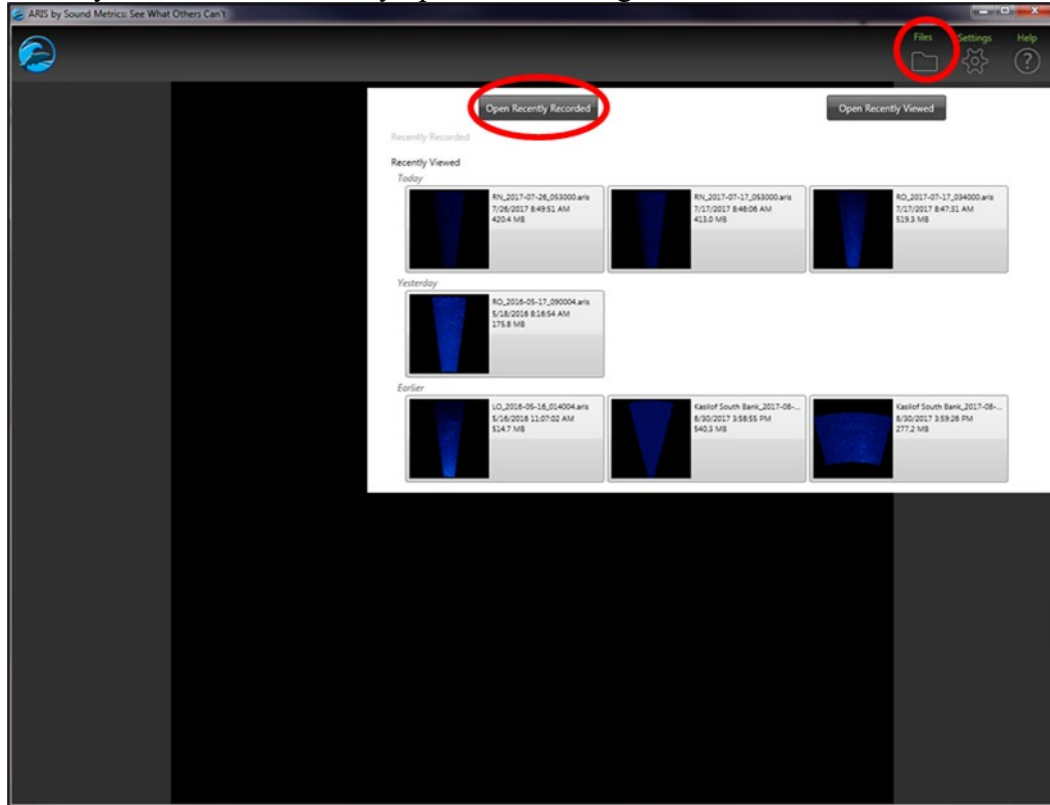
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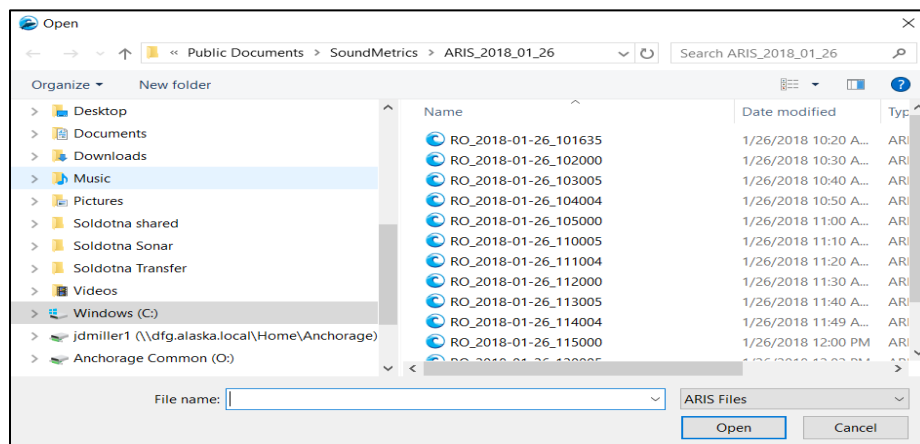


2) Open first file to measure

- a) Click on the “File” icon in upper right corner of window. This displays a list of recently recorded and recently opened .aris image files.

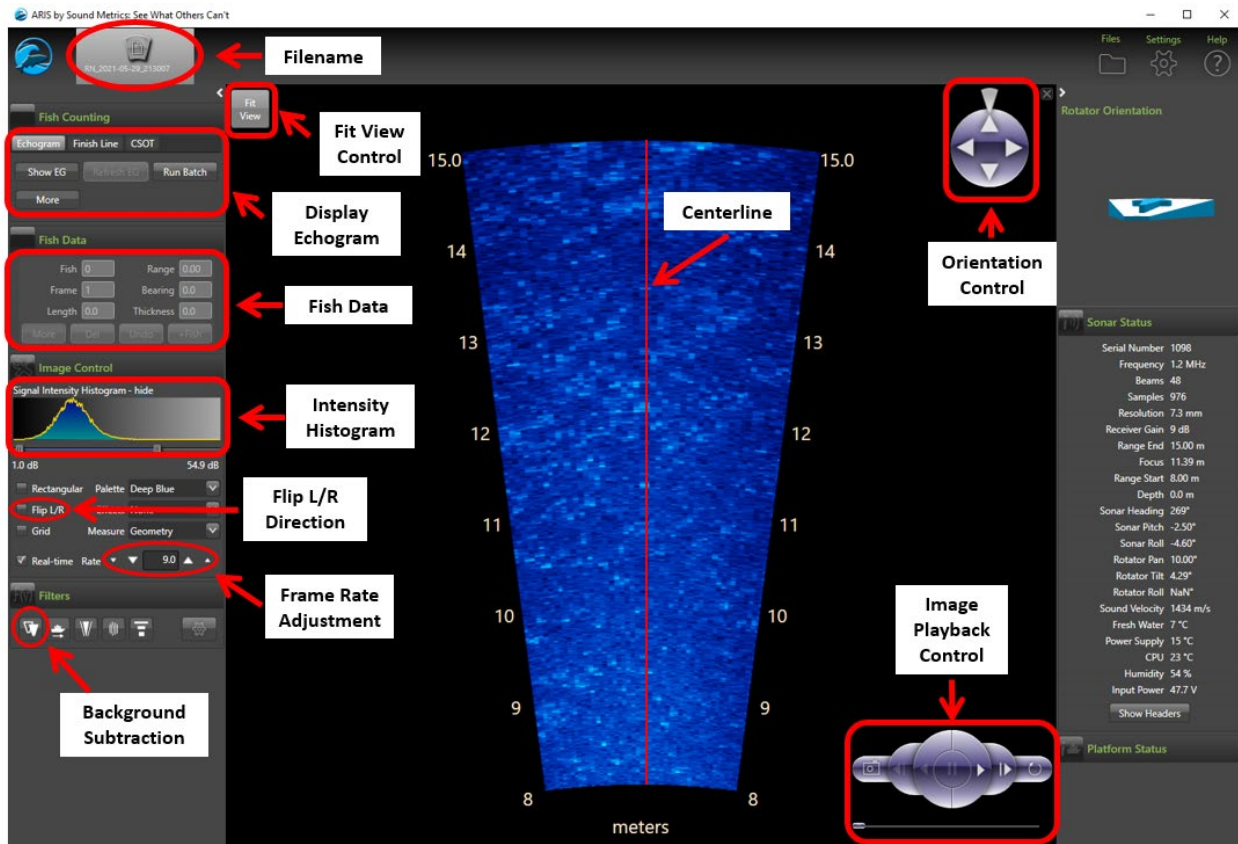


- b) Click the **Open Recently Recorded** button to open a file browser to the last saved files.
- c) Navigate to the appropriate directory and open a file.



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- d) Ensure you have opened the correct file by checking the filename in the Open File Icon at the top left of the window.
- e) The ARISFish display should look similar to the image below. Note the various elements used to display and measure fish images:



- i. **Echogram** – Allows user to display echogram, select direction of travel, and enter Editor ID.
- ii. **Fish Data** – Displays metrics of measured fish.
- iii. **Signal Intensity Histogram** - Ensure that the slider buttons under the histogram are position such that the entire histogram lies between the two buttons. The sliders can be adjusted slightly to produce the best contrast between fish images and the background.
- iv. **Flip L/R** - If desired, can reverse the left and right sense of the displayed sonar image.
- v. **Rate** (frame rate) - The recorded frame rate appears here when the file is first opened. Frame rate can be increased or decreased by using the triangular up/down buttons.
- vi. **Background Subtraction** icon - click this button to remove static background from the displayed sonar image. Use background subtraction if fish images are difficult to differentiate from the background.
- vii. **Fit View Control** - The sonar image can be zoomed in or out by using the

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zoom wheel on your mouse or by swiping two fingers on your laptop touchpad. The *Fit View* button will resize the view to show the entire image at its maximum size within the main display panel.

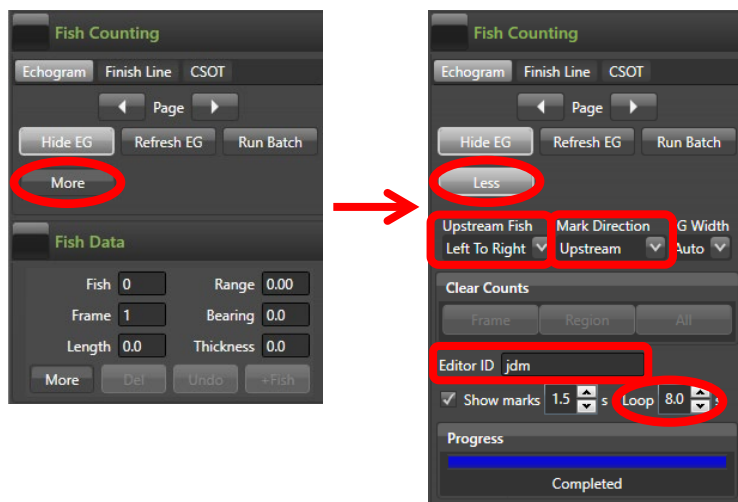
- viii. **Orientation Control** - Allows you to rotate the image orientation by either clicking one of the four triangular buttons (rotates 0, 90, 180, 270) or by clicking and dragging the "wedge" control on the outside of the circle to the desired percent rotation.
- ix. **Image Playback Control** - Can be used to play forward, play backward, advance single frame forward, advance single frame in reverse, and pause by clicking the appropriate button. Can also use slide at bottom to advance forward or backward to desired point in file.

### 3) Display Echogram

- a) Click the **Background Subtraction** icon and wait 30 seconds or so for background to subtract

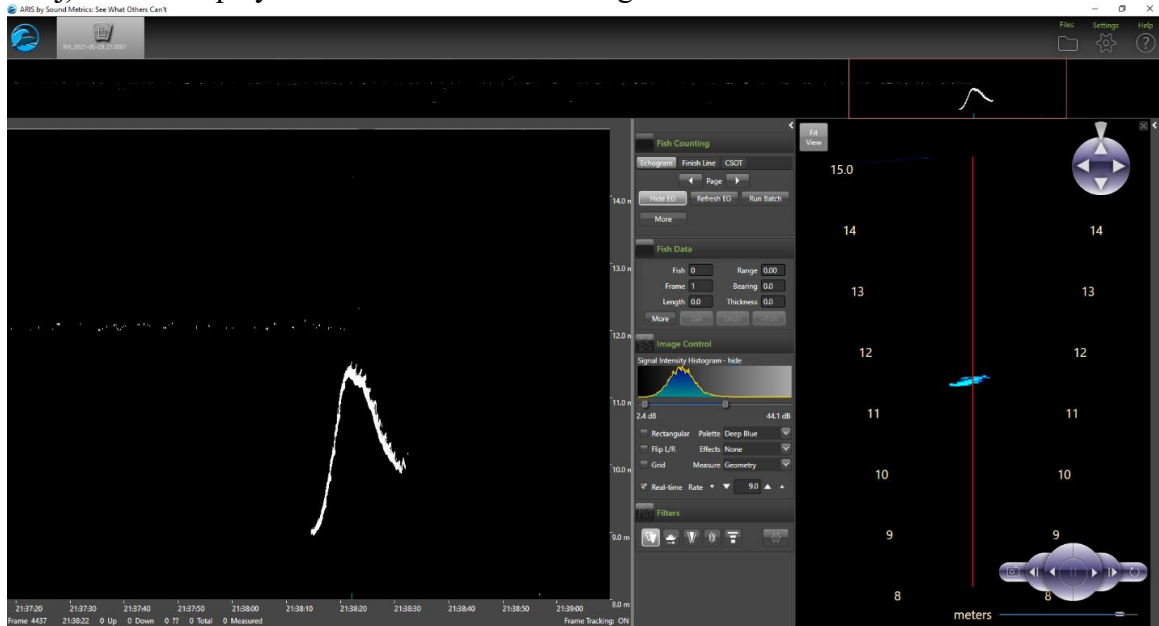


- b) Then click **Show EG** in the **Echogram** tab at the top to display the Echogram.
- c) You may be prompted to enter your Editor ID and upstream fish direction. Press OK.
- d) Click the **More** button under the **Echogram** tab - this will expand the panel to show echogram controls
- e) Ensure **Mark Direction** is set to "Upstream" using the drop-down arrow
- f) Then set the **Upstream Fish** direction ("Left to Right" or "Right to Left")
- g) Enter your initials in the **Editor ID** box
- h) Ensure **Loop** length is set to at least 8 seconds
- i) Then click the **Less** button to hide the echogram controls.



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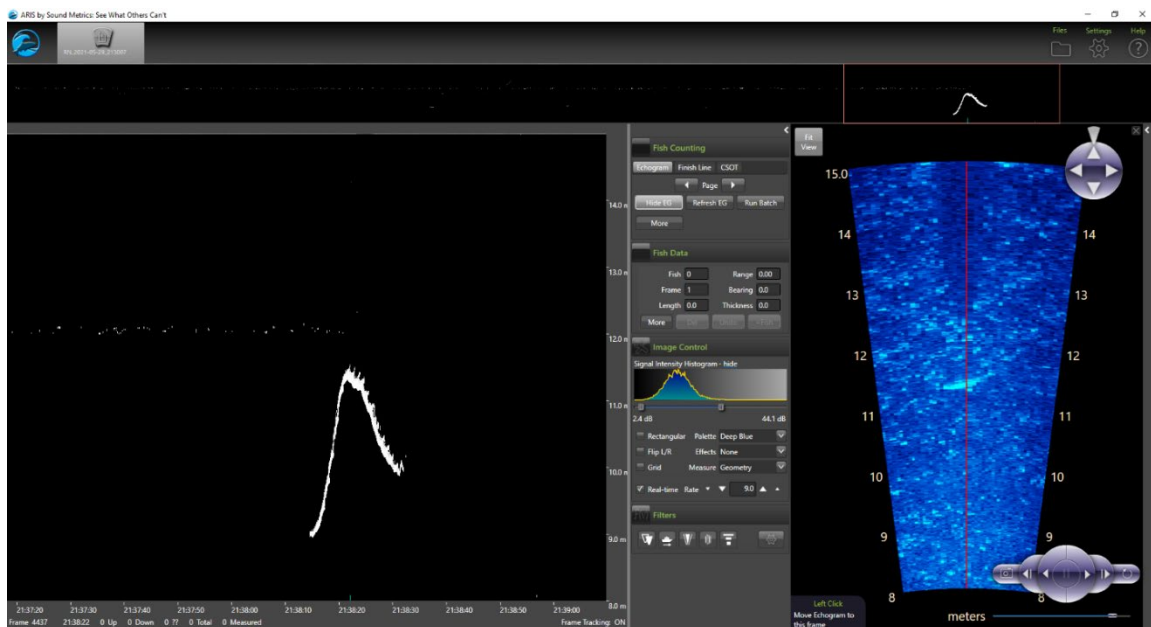
j) Your display should now look something like this:



k) Click the **Background Subtraction** icon on Filters Menu again to turn background subtraction off on the video image. **Failing to turn background subtraction off prior to measuring fish image length may result in an underestimate of actual fish length**<sup>10</sup>.

l) Set **Signal Intensity** sliders to optimize video image for measuring fish.

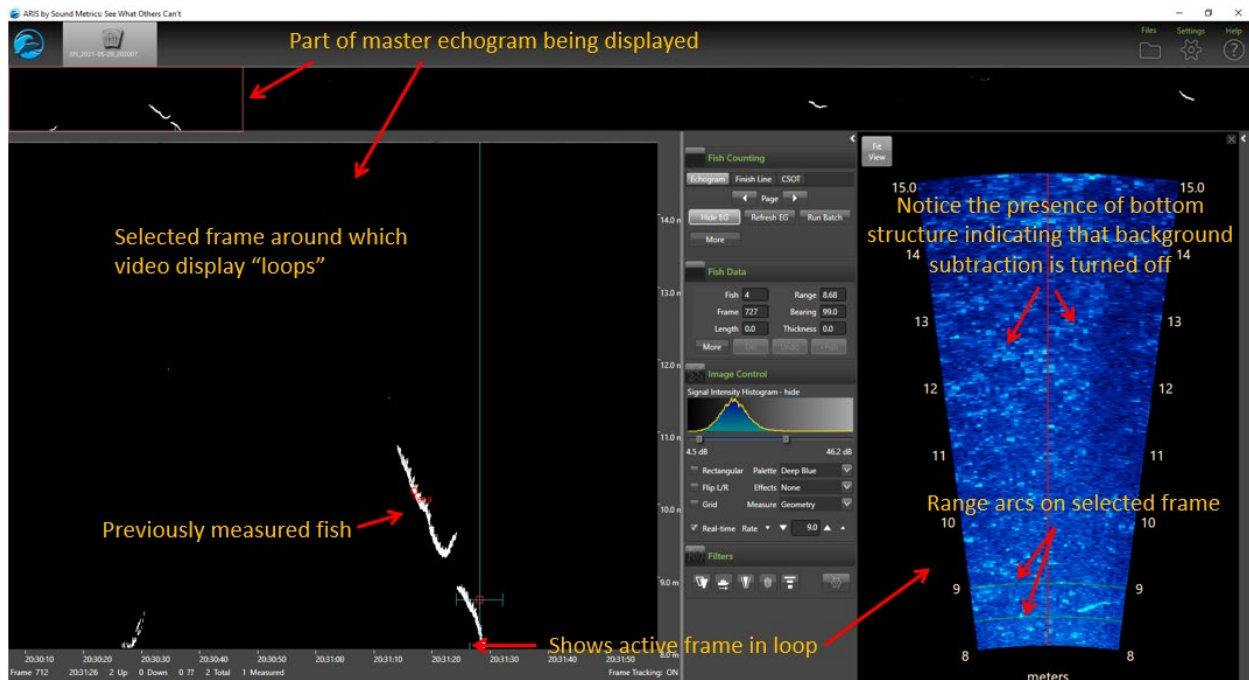
m) Your overall display should now look similar to this:



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#### 4) Manual Fish Length Measurements

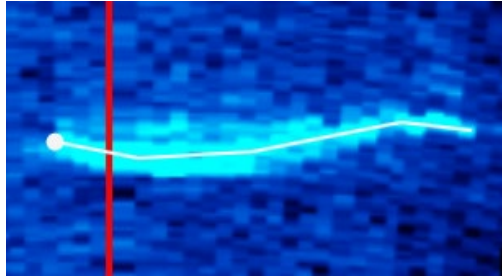
- a) Ensure **Background Subtraction** is toggled **off** as described in step 3.k. above.
- b) In the echogram window, Left Click on fish trace to be measured (Puts red square on fish trace).



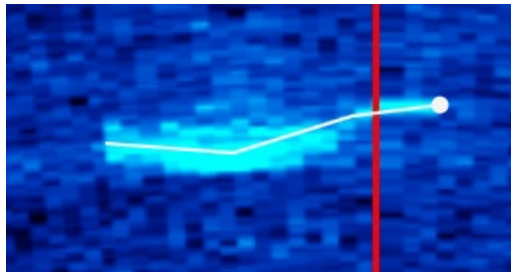
- c) Right click inside the red square (automatically activates the movie showing the fish bounded by range arcs).
  - i. Press **spacebar** on keyboard to **start or stop** the video playback.
  - ii. Use **right arrow** and **left arrow** on keyboard to step through video one frame at a time to find a frame that displays the entire fish length well.
    1. Measurements should be taken from frames where contrast between the fish image and background are high and where the fish displays its full length.
    2. In general, the best images are obtained when the fish is sinusoidal in shape (see image below) rather than straight and/or perfectly perpendicular to the center axis.
    3. Watching the behavior of the head and especially the tail over several frames, and taking several measurements, is often helpful in distinguishing the best frame.
  - iii. To zoom in, **right click and drag** mouse cursor over the video display or use mouse roller while cursor is positioned in the video display window.
  - iv. To zoom out, select the <v> key on the computer keyboard or use the mouse roller while cursor is positioned in the video display window.

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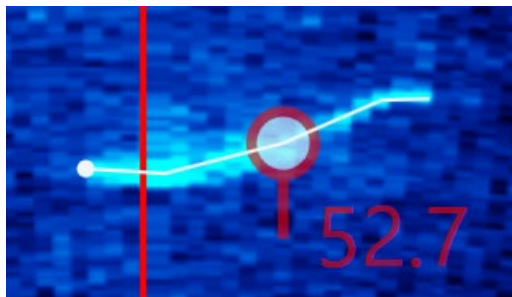
- v. **Left click, hold, and drag** mouse cursor in video display window to **move video display** within the window.
- d) Measure Fish Image
  - i. Fish traveling snout-first upstream or downstream – **Left click** on the fish snout and continue to **left click** along the midline of the fish to create a “segmented measurement.” The segments should follow the midline of the body of the fish, ending at the tip of the tail.



- ii. Fish backing downstream through the beam tail-first - **Left click** on the fish tail and continue to **left click** along the midline of the fish to create a “segmented measurement.” The segments should follow the midline of the body of the fish, ending with the tip of the snout.



- iii. Toggling background subtraction on and off can sometimes be helpful in determining the actual end of the tail or snout.
  - iv. If necessary, select <u> key to undo last measure segment or <d> key to delete all measure segments.
- e) Select <f> key to add measurement to the .txt file – you will see measurement in red
- f) Select <v> key to unzoom video display window (not necessary if you have another fish in the same proximity that you want to measure).



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- g) Move on to the next fish image and repeat steps 4.b. through 4.f.
- h) Occasionally press <e> to save your work on each sequence when complete (or before you divert to another task).
- i) **Left Click** on Master Echogram to advance to new echogram section
- j) Once finished measuring the current file, advance to the next file:
  - v. Click **Background Subtraction** button to turn background subtraction on.
  - vi. Press *Alt+Right Arrow* or click the "File" icon in upper right corner of window to navigate to the next file using the file browser.
  - vii. Once new file is open in ARISFish, click **Background Subtraction** to turn background subtraction off. Now ready to begin measuring next file.
- 5) Hot keys used in measuring fish in ARISFish software.
  - a) <e> to “save” all echogram measurements to file
  - b) <f> to “fish it” (to accept the measurement and display it on the echogram)
  - c) <u> to “undo” the last segment
  - d) <d> to “delete” all segments
  - e) <space bar> to pause in movie mode
  - f) <right arrow> forward direction when you play movie or advances frame one at a time if the movie is paused
  - g) <left arrow> opposite of above
  - h) **Left Click Drag** to show movie over the selected time
  - i) **Right Click Drag** zooms the selected area in the video image when an echogram fish is selected
- 6) Instructions for including or excluding fish to be counted or measured
  - a) To optimize the aim of the sonar beams relative to the bottom of the river, theinsonified zone is often divided into individual range strata that are sampled separately. To avoid over counting fish as they cross stratum boundaries, we apply the “centerline rule” where a fish is not counted unless it crosses the centerline of the sonar beam. The figure below demonstrates the potential for overcounting without applying this criterion.
  - b) **Summary of fish measurement rules**
    - i. For a fish to be considered valid for measurement, it must cross the centerline.
      - 1. If a fish enters or exits the beam on the near- or far-range boundary (beginning or end range), the snout of the fish must cross the centerline before it can be considered a valid fish to measure.
      - 2. If the snout of the fish enters the near- or far-range boundary right on the centerline, the fish should be considered valid for measurement.
    - ii. Exclude fish that hold throughout the length of the sample.
    - iii. Exclude fish that are holding at either the beginning or the end of the sample.
      - 1. Fish that are actively migrating (not holding) as the sample begins or ends should be considered valid targets for measurement as long as they cross the centerline.

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- iv. Exclude fish that enter the beam from downstream and then exit the beam downstream (do not measure even if they cross the centerline).
- v. Exclude fish that enter the beam from either upstream or downstream, fail to cross the center line, then disappear from the image.
- vi. Exclude fish that enter the beam from either upstream or downstream, fail to cross the center line, then disappear from the image.
- vii. Use the video image to identify actively migrating fish when several holding fish are present. If you have several fish holding throughout the sample, use the video mode or run your cursor across the echogram while watching the ARIS video image to observe fish that are actively transiting the field of view. Measure fish that are actively transiting the field of view and that meet all criteria listed above.
- viii. Consult with others if you come across a questionable trace (fish) or are unclear of the rules listed above.

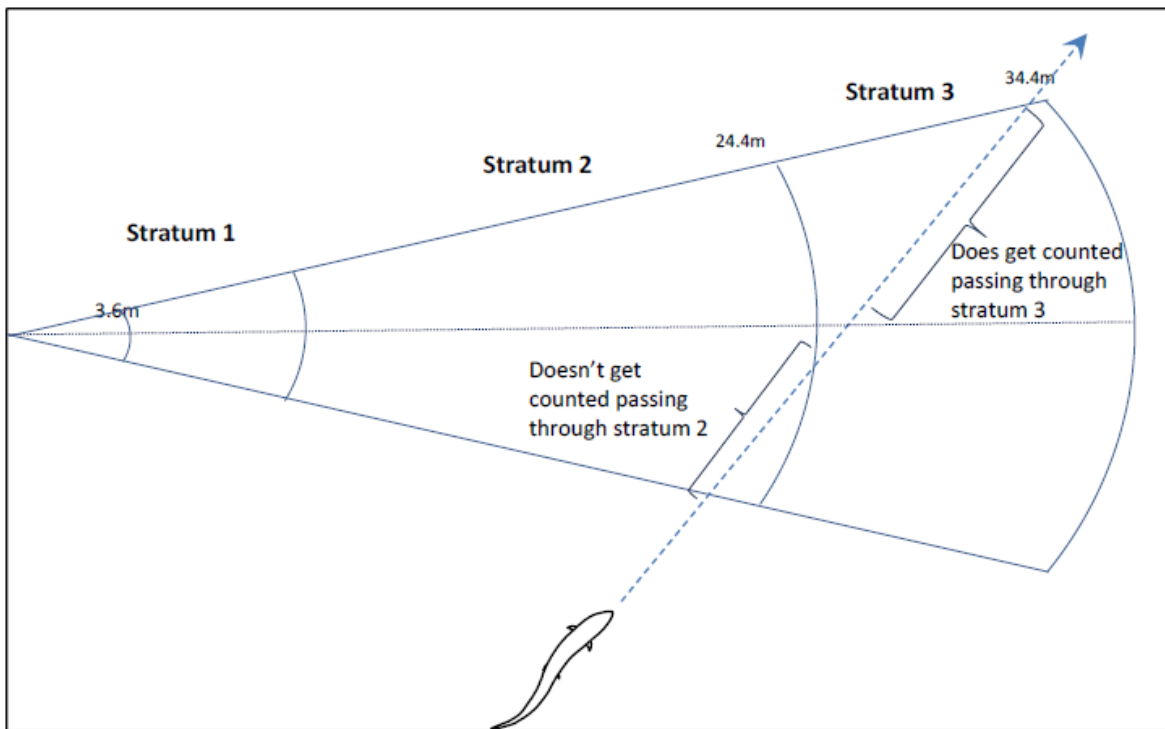


Illustration of the problem of double-counting. *Note:* To avoid counting this fish in both stratum 2 and stratum 3, the fish will only be counted in stratum 3 where it crosses the centerline of the beam.

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## 7) ARISFish Output

- a) Fish measurements are recorded to a text file (\*.txt) that is saved to the same folder that contains the ARIS data file. The text file appears as follows:

**Counts of measured fish (up, down, and total)**

Total Fish	=	3
Upstream	=	2
Downstream	=	1
??	=	0

**Metrics of each measured fish (Frame number, direction of travel, range [m], position off axis [degrees], and length [cm])**

File	Total	Frame#	Dir	R (m)	Theta	L(cm)	HR(cm)	L/dR	Aspect	Time	Date	Latitude	Longitude	Pan	Tilt	Roll	Species
1	1	323	Up	14.48	2.3	85.3	0.0	0.00	0.0	09:01:30	2021-08-01	N 00 d 0.00000 m	E 000 d 0.00000 m	2.49	0.00	0.00	Unknown
1	2	1668	Down	13.62	0.0	100.5	0.0	0.00	0.0	09:07:29	2021-08-01	N 00 d 0.00000 m	E 000 d 0.00000 m	2.49	0.00	0.00	Unknown
1	3	1975	Up	15.97	-10.1	110.8	0.0	0.00	0.0	09:08:55	2021-08-01	N 00 d 0.00000 m	E 000 d 0.00000 m	2.49	0.00	0.00	Unknown

\*\*\* Source File Key \*\*\*

- Source File Name: C:\Users\jdmiller1\Desktop\2021 Inseason\Kasilof\8-1-21\North Bank\NB\_2021-08-01\_090000.aris
- Source File Date: 8/3/2021
- Source File Start: 09:00:02
- Source File End: 09:09:59

Settings

Upstream: Left To Right

Default Mark Direction: Upstream

Editor ID: jdm

Show Marks: True

Show marks for 1.5 seconds

Loop for 8.0 seconds